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SBE16 Towards Post-Carbon Cities

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FASUDIR Friendly and Affordable Sustainable Urban Districts Retrofitting

POCACITO european post-carbon cities of tomorrow

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EU low carbon & energy security MILESECURE-2050

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IN THIS ISSUE

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A BRIEF INTRODUCTION TO THE SBE CONFERENCE SERIES

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iiSBE - International Initiative for a Sustainable Built Environment

The Torino SBE16 conference was part of a series of conferences that focus on sustainable building and construction. The series was launched in 2000 and includes four international organizations as co-owners:

- *International Council for Research and Innovation in Building and Construction* (CIB, www.cibworld.nl)
- *International Initiative for a Sustainable Built Environment* (iiSBE, www.ii-sbe.org)
- *Division of Technology, Industry and Economics* (DTIE) of the *United Nations Environment Programme* (UNEP-SBCI, Sustainable Building and Climate Initiative, www.unep.org/sbci/)
- *International Federation of Consulting Engineers*, www.fidic.org

The SBE conference series is now considered to be the pre-eminent international conference series on sustainable building and construction. The series is held on held on a three-year cycle with planning and preparation in year 1, national/regional conferences held in year 2 (2016 In this cycle), and a single global event to be held in year 3. Later this year, a proposal call will request expressions of interest for participation in the 2019-20 cycle.

The series places a core emphasis on peer-reviewed papers, presentations of regional policy papers, displays of pre-evaluated projects and a small number of high-quality commercial exhibits. These events also provide fast-track inclusion of the best technical papers from national/regional conferences into the global event, as well as registration policies designed to encourage the attendance of students and delegates from developing countries.

Twenty national/regional conferences are confirmed for 2016 and Hong Kong has been selected as the site of the World SBE17 conference, to be held in early June 2017.

In all of these conferences, one or more local research-based organizations have taken financial and organizational responsibility while iiSBE, CIB and UNEP-SBCI, as the international series owners, have given organizational advice and have used their networks to help ensure a large multi-disciplinary audience for the events.

The increasingly high reputation of the series has resulted in other research groups and organizations holding events concurrently with these events, thereby maximizing the benefit for delegates. In short, the SB-series of conferences provides delegates with an unparalleled view into national, regional and international sustainable building issues every three years, while providing host organizations with increased visibility and effectiveness in their own regions.

The series continues to evolve. Up to and including 2013 the series was titled the “SB” or *Sustainable Building* conference series, but the series partners have now changed the series name to “SBE”, standing for *Sustainable Built Environment* series, to more clearly indicate the inclusion of issues related to local urban areas and supporting infrastructure. There is also an increasing emphasis on continuity, reflected by the establishment of a Panel of Advisors, consisting of global conference organizers going back to 2000, and an increased emphasis on having the World SBE conference organizers participate in the national/regional SBE events.

SBE16 TORINO BRINGING TOGETHER RESEARCH AND URBAN STAKEHOLDERS

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Today more people live in urban areas than in rural areas (54%). In 1950, only 30 % of the world's population was urban. By 2050, 66 % of the world's population is projected to be urban. 90 % of the increase by 2050 will be concentrated in Asia and Africa. The consequence is that sustainable development challenges and issues will be concentrated in cities, particularly in the lower-middle- income countries where urbanization processes are more relevant. In the same time in Europe the construction sector represents around 42% of final energy consumption and 36% of CO_2 emissions and is a major consumer of intermediate products (raw materials, chemicals, electrical and electronic equipment, etc.). The main reason for the huge impact of the European building sector on the environment is the low energy efficiency of the existing building stock that for more than the 70% was built before the first energy crisis (1970's decade). It has been estimated that 3% of the total EU building stock would need to be deep-renovated each year for the next 40 years to meet EU 2020 and 2050 energy, carbon and economic goals. To improve the sustainability of the built environment, it is clear that the building scale in not the more appropriate. The issue has to be managed at urban scale where it is possible to profit for potential synergies between buildings and other possible contributions. The role of cities in reducing the impact of the building sector is of fundamental importance. The SBE16 Torino conference addressed this issue from the point of view of policies, decision making processes, assessment tools, methodologies, case studies with a particular attention on the results of the most innovative research projects in the field of urban sustainability.

The event involved more than 10 European Research projects at urban scale from different programs (Interreg - territorial cooperation, H2020 - innovation and PPP partnership, etc.). A networking event has been organized between the projects in cooperation with CESBA (Common European Sustainable Built Environment Assessment), the European initiative for the harmonization of sustainability assessment standards. The concept of an International Sustainability Passport for cities and neighbourhoods has been discussed as the possibility to define common metrics and indicators to measure the performance of urban areas. In particular, the EU FP7 project FASUDIR (Friendly and Affordable Sustainable Urban Districts Retrofitting), one of the promoters of the conference, showed how indicators and assessment tools could be the core of efficient decision making processes to improve the sustainability of cities and districts. A session has been also devoted to policies, as a main driver to start the change. The conference has been organized with the support of the City of Torino and it has involved several other public organizations. Possible policies based on incentives and new business models have been discussed and specific recommendations for policy makers drafted.
Only with a system action involving all the stakeholders of the building sector, the users and the communities in particular, will allow to reach a real improvement. This has been the spirit of the SBE 16 Torino: to actively involve all the participants with different backgrounds in exchanging views and visions and to identify synergic actions for post carbon cities.

SBE16 TORINO
TOWARDS POST CARBON CITIES
AN INTRODUCTION

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Cities are today recognized for their key role in the fight against climate change, at the international level (Vidalenc et al., 2014). In particular, cities are becoming the focal point of climate change mitigation strategies because they are able to respond to disturbances in their external environments in addition to internal environments (Evans 2008). Cities are here understood not only as local authorities but as complex, adaptive, social-ecological systems, including local ecosystem of inhabitants, companies, public utilities and local governments.

Furthermore, urban population growth creates pressure on the environment (resource consumption, especially energy and land use) and the urban economic (financing of infrastructures, financing of public services) and social (health impacts, air pollution, noise pollution; employment; social integration, quality of life) systems. This pressure is likely to increase, producing a strong impact on urban metabolism. Cities currently consume 75% of energy and are responsible for the production of about 80% GHG (Greenhouse gas) emissions globally (IEA, 2008; UNEP, 2012; IPCC, 2014). This large consumption of environmental and energy resources is often accompanied by strong social inequalities (ESPON, 2010).

In recent years, the "Post-Carbon City" has emerged as a concept as it emphasises the process of transformation, a shift in paradigm, which is necessary in order to respond to the multiple challenges of climate change, ecosystem degradation, social equity and economic pressures. According to the EU POCACITO project – POst-CArbon CIties of Tomorrow: foresight for sustainable pathways towards liveable, affordable and prospering cities in a world context (SSH.2013.7.1-1), this concept has emerged from a rupture in the carbon-dependent urban system that has lead to high levels of anthropogenic greenhouse gases. More specifically, the term "post-carbon" emphasizes the process of transformation, a shift in paradigm, which is necessary to respond to the multiple challenges of climate change, ecosystem degradation, social equity and economic pressures. Post carbon cities must reach a massive reduction of greenhouse gas emissions (GHG) to reach the targets posed by the European Commission in 2011, launching the Energy Roadmap - "Roadmap for moving to a competitive low-carbon economy in 2050" (COM 2011, 112). This involves a cut in the EU greenhouse emissions by 80 % by 2050 (compared with 1990 levels) entirely through measures taken within Europe. To achieve this, intermediate GHG cuts of 25% by 2020, 40% by 2030 and 60 % by 2040 would be needed. This policy has been reinforced at international level at the Conference of Parties, COP21, in Paris, last December 2015. This implies the establishment of new types of cities that are zero-carbon as well as environmentally, socially and economically sustainable.

According to Loorbach (2014), the process towards post carbon city can be understood as the aggregation of a number of underlying transitions and incremental processes of experimentation, breakthrough, institutionalization, behavioural and cultural change (he talks of a "socio-economic revolution"). All these processes are mainly driven, in our Western democracies, by distributed control, renewable resources and systemic innovation, representing a "fundamental power shift away from powerful elites controlling resources, money and power towards diverse and distributed forms of collaboration between professionals and citizens".

The EU MILESECURE-2050 project, "Multidimensional Impact of the Low-carbon European Strategy on Energy Security, and Socio-Economic Dimension up to 2050 perspective" (SSH.2012.2.2-2) has revealed that policy-makers may be ignoring the "human factor" in energy transition to the detriment of rapid and significant change across Europe. This implies significantly less emphasis on technology and on top-down planning and more emphasis on the enabling of both individuals and social groups to articulate themselves and participate in the energy transformation.

In short, the human factor becomes the driver of energy transition in at least three distinct levels: i) the set-up of energy production and consumption becomes more visible and closer to citizens; ii) the energy issue becomes a direct interest of citizens who actively participate in the regulation, orientation, management (also in economic terms) and monitoring of measures and policies of energy transition; iii) there is a strong personal effort on the energy transition through an intense emotional involvement.

In conclusion, the transition toward "post-carbon city" requires that citizens and all private consumers are more aware, active, energy sufficient, as well as being a prosumer producing energy for their own consumption, where this is possible.

At the same time, this transition imposes new paradigms in the policy makers agenda. It requires a burst in the carbon-dependency of our urban systems, which has lead to current high levels of greenhouse gases. Hence, to tackle sustainability challenge towards post-carbon cities, urban planning policies must be identified that not only look at technology-related issues ("smart city" paradigm), but also at citizens behavior and to how they respond to building performances and available urban services. For instance, when the urban community is well self-organised, and can rely on traditional knowledge about coping with changes without external help, resilience increases and disaster/emergency response gives better outcomes. Management can destroy or build resilience, depending on how the social-ecological system organises itself in response to management actions (Folke et al, 2002; Ernstson et al, 2010). Thus, resilience, for social-ecological systems, can be defined as the capacity of a system to cope with change, either trough persistence, adaptation or transformation (Korhonen & Seager, 2008). The study of the transition towards future production and consumption systems involve not only a more efficient usage resources but also a resilience building among communities. In this context, innovative case studies are those related to sustainable university campuses. The concept of "Living Lab" takes students, teachers and administrative staff as "citizens" of a portion of the city. In addition, the vast partnerships among universities and among academia and its environment lead many universities to assume a highly ambitious role of collaborating with diverse social actors to create societal transformations in the goal of sustainability.

Unfortunately, the available literature in the field tend to be either engineering-led without understanding socio-economic complexities of both the building market and the urban forms, or simply qualitative based on small surveys and case studies. This gap influences negatively sustainable urban planning policies.

In the current transition, new uncertainties and vulnerabilities of cities are emerging, that require an holistic evaluation approach and new integrated collaborative methods and tools with the aim at assisting urban planners, built environment stakeholders and policy makers in their efforts to plan, design and manage post-carbon cities.

The papers presented at the Sustainable Building Conference 2016 in Turin last February 2016 has revealed new research directions and scientific outputs in the above topics, reflecting on all the followings:

1. Systematic Approaches to Sustainability
2. Sustainable University Campuses
3. Assessment Methods and Tools
4. Sustainable Urban Districts Retrofitting
5. Policies & Regulations for a Sustainable Built Environment
6. Urban Infrastructure for Post-Carbon Cities
7. Decision Making Methods and Tools at Urban Scale
8. Sustainable Districts: Case Studies
9. Buildings for Post-Carbon Cities

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Systematic Approaches to Sustainability

URBAN SYMBIOSIS, A NEW PARADIGM IN THE SHIFT TOWARDS POST-CARBON CITIES

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sewage systems

Abstract

The metabolic flows of cities have to be reduced. Thus far, efforts have been mainly directed to providing the city with renewable resources, diminish resource consumption, and/or reuse the wastes and emissions.
The dense fabric of urban infrastructures does not only provide a high level of services. By the proximity of infrastructures symbiosis might be created between them. This urban symbiosis might lead to a considerable reduction of resource consumption and/or carbon- and other emissions of all systems involved. However, developing symbiosis between urban infrastructures implies that the owners/operators of the infrastructures are able to align their interests too. This might be problematic as infrastructure operators developed a culture of autonomy. Moreover, they are nowadays owned by various public and private entities that pursue different agendas.
The top down planning model of infrastructures appears to be at the end of its life cycle; citizens, businesses and NGO's request participation. Early participation, using future methods and workshops might contribute to align actors for promising urban symbiosis options.
The paper analyses barriers in developing urban symbiosis and sketches strategies how to deal with them. It uses the example of urban waste water systems to sketch strategies to develop symbiosis between urban infrastructures.

1_Introduction

Cities have been transformed in various phases in recent history; industrialisation led to large scale urbanisation and the creation of large belts of relatively poor housing. More recently, new transport systems, and especially the car and freeways fuelled suburbanisation. It created another belt of commuter towns and urban sprawl. With the advent of ICT's a confluence of urban and rural development was foreseen, as a lot of jobs would no longer be tied up with urban areas. The dichotomy between urban and rural areas was supposed to fade away (Muhammad et al., 2008). That did not happen, on the contrary. ICTs did not stop urbanisation but even fuelled it, as teleworking only marginally substituted the traditional character of office work. Urban areas became economically and culturally even more attractive as they became the centres of the new ICT industry.
Hence, it seems likely that urbanisation will continue in the next decades, in the developing world as well as in the industrialized world.

1.1_Urban Symbiosis

City dwellers consume more resources than inhabitants of rural areas. Hence, reducing the footprint of the urban dweller is of utmost importance. Moreover, the world's giant cities are depending on world-wide supplies of resources, which makes them vulnerable to military conflict and natural catastrophes. Interruptions in crucial supply systems might create a series of subsequent catastrophes. Hence, urban resilience is of great importance (Ahern, 2011)
Cities have scope to improve. For example, current urban systems are generally quite inefficient. Moreover, the growth of cities creates scope for

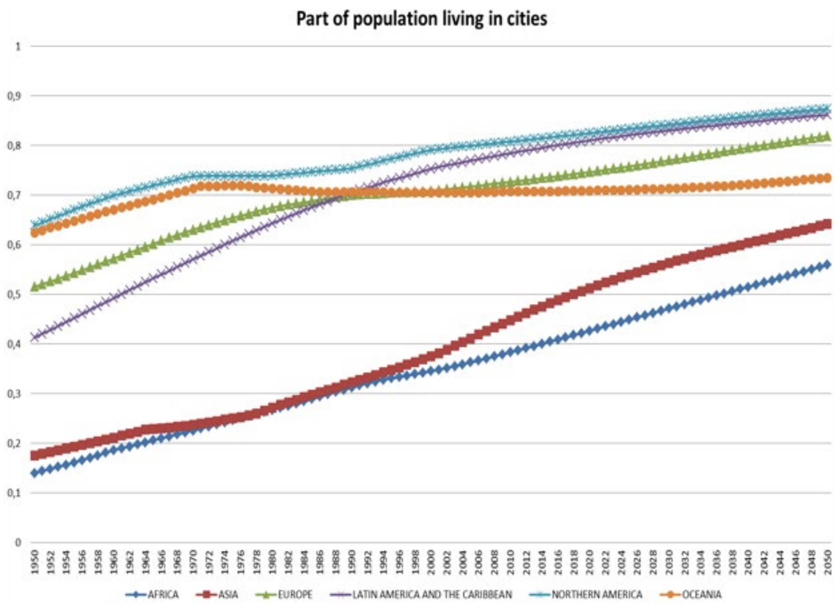

Figure 1. Based on data of (UN Department of Economic and Social Affairs, 2014).

renewal, as technological innovation in urban systems can be far better achieved in new (Greenfield) urban districts. Moreover, cities are nodes in the societal innovation system as research and development and higher education institutes are usually concentrated in cities (Hekkert et al., 2007).

Besides improving separate urban systems, improvements might be achieved by analysing/managing the urban metabolism at a higher level. Innovation has been studied as a 'process of inventions conquering the world' but innovation might also take place between existing systems: systems might aim at gaining from each other's proximity or do just have to appear in couples (Mulder and Kaijser, 2014). The concept 'Urban symbiosis' has been introduced by several authors to denote innovations creating symbiosis between urban systems (Mulder, 2015; Van Berkel et al., 2009; Vernay, 2013). The concept was the equivalent of the concept of Industrial Symbiosis: "Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity" (Chertow, 2000).

Cities are an important scale in innovation (Raven et al., 2012). As cities are organisational as well as infrastructural nodes, developing symbiosis between urban systems could be an important goal for innovation. However, urban symbiosis as a praxis is rather old: its' best known example is probably the combined generation of power and heat, which boosts the overall efficiency of heat and power generation (Mulder, 2015).

1.2_Barriers for urban symbiosis

Urban symbiosis is not an easy fix, or a low hanging fruit. There are several barriers which could be categorized as:

- Technological. By-products of one system might not comply with the input requirements of the other, or the production of by-products does not match the demand for them in time (waste heat in summer, heat demand in winter). Storage, transport and distribution systems might be required. These

[1] During a symposium in Delft, March 19th 2010, Chris Jordan, manager at the Rotterdam industrial network association Deltalinqs made a similar observation for industrial symbiosis in Rotterdam.

technological barriers might be solved but at a considerable cost. Storage and/or transport require space and money and might lead to a lower quality resource.

- Institutional. Infrastructural systems are run by organisations that generally develop a culture of autonomy. Autonomy provides them with most opportunities to cope with any barriers (or reverse salients in Tom Hughes work on technological systems development (Hughes, 1985)) that develop during the life time of systems. This implies that urban symbiosis might be applied as long as it does not affect the system's autonomy, i.e. it might be terminated without interrupting the system's operations. Long term contracts and larger investments in urban symbiosis, however, curb the autonomy of the participants and are therefore generally avoided[1].
- Technology history. Infrastructures are in general extremely 'locked in' (Arthur, 1989). The lock in results from the long term character of the investments: Drinking water pipes from the 19th century are sometimes still in use, sewage pipes might last for 80 years, a road might last for 30 years with only marginal maintenance costs. Moreover, a lot of know how exists regarding the system as it is; alternatives require developing new know how, and the unknown might bring risks. Hence, every idea for encompassing symbiosis between infra systems might be objected by the risk that a large amount of assets might be lost if symbiosis is no longer needed. It is not just the loss of assets by a transition. A better system might be known, but there might be no feasible pathway to reach that ideal starting from the current system (e.g. it is almost impossible to switch from right- to left-side driving, or to switch from railway gauge (Puffert, 2002)). This strong lock-in creates a strong preference for add on innovation, contributing in fact to the build-up of additional lock in for the pre-existing infrastructure (Frantzeskaki and Loorbach, 2010).

2_Strategies for change, the example of the sewage system

Given the strong technological and institutional barriers and the strong lock in, it is by no means clear which strategies are able to create urban symbiosis innovations (Pandis Iveroth et al., 2013). In the remainder of this paragraph I will sketch some options for urban symbiosis type innovations in the urban waste water system, and strategies to achieve these innovations.

2.1_Introduction: the waste water system

The urban waste water system is an interesting system as it has options for developing symbiotic relations with various other systems:

- Gas, a waste water treatment plant might produce biogas (methane), which might be treated to be injected into the gas grid (Vernay, 2013)
- Heating; sewage is warm, the heat might be recovered for heating purposes. Effluent of the sewage treatment might also be used for heating purposes.(Tassou, 1988)
- Electricity; biogas could be used in a combined heat/power installation to produce process heat for the sewage treatment and electricity for the pumps and to supply to the grid (Björklund et al., 2001).

- Agriculture; the residue from the sewage treatment process might be used to fertilise agricultural land. However, pollution should be prevented.
- Resource supply. Various resources, like struvite and metals might be recovered from the sewage (Uysal et al., 2010).
- Surface water quality. Waste water systems often also deal with storm water. During downpours, raw sewage might be emitted to open water, which might be devastating for water quality. Effluent emissions might also create 'thermal pollution', especially in winter.
- Drinking water; in regions with water scarcity, effluent of the waste water treatment plant might be upgraded to drinking water quality. This is generally far cheaper than seawater desalination. However, there are strong objections against drinking water that originated from sewage. Small residues of pharmaceuticals might still be present, like they are present in much drinking water (Benotti et al., 2008).

Some of the barriers to urban symbiosis might be an issue of developing improved technology, some might be an issue of removing institutional barriers, and some might be an issue of a long term strategy in order to cope with lock in. However, it is not always a priori clear what the nature of a barrier is:

- If a new, improved technology is developed, other solutions are not required. This is generally the 'easy way out'. However, not all problems are technologically solvable. Moreover, a new technology is only rarely identical in performance/costs/operation to the previous technology.
- Innovating institutions might be another option to create change.
- The last strategy might be to introduce new systems for new urban areas and gradually substitute the old ones, once they are due to be replaced.

For all these strategies, one needs foresight: it is not so important what prices, technology or regulation might do today; it is important to recognise what might happen, or probably not happen in the future and how a system might deal with change.

2.2_Visioning

Crucial for working on encompassing change in urban systems is not to start from the locked in systems but from needs to be fulfilled and the basic conditions to be met. Options for technologies could be scanned that comprise a promise to fulfil (part of) these needs. This could lead to a future vision developed in an interactive process with stakeholders. It is important to start visioning in needs to fulfil and not in technologies to be adapted: visioning allows 'wild ideas', while technological improvement only allows a better version of 'what is' (Mulder et al., 2012). In practice, visioning hardly occurs in sectors that are heavily locked in.

A long term vision that is widely supported by main stakeholders creates a framework that can act as a guidepost for innovation: what innovation do we need to move into the right direction, what organisational change and policy change might be required, and what innovations might be regarded as 'dead end streets'. Translating future visions into concrete strategy is called backcasting.(Holmberg and Robèrt, 2000; Quist, 2013; Robinson, 1988).

A future vision for a wastewater system will define key elements like: individual or collective, if collective its optimum scale, substances to be handled by the system (and substances that should be prevented to enter the system), the way how to treat the waste water, and what substances and forms of energy to recover.

2.3_Technological Change Strategies

The vision might define technologies to be changed (in general one aims for 'improvement' i.e. higher efficiencies, but adaptation to new conditions, or adaptations to deal with side effects might also be important). Technological change might be sought by:

- Stimulating relevant research & development
- stimulating experiments with alternative technologies, and protecting these experiments (Kemp et al., 1998),
- Creating new demands that technologies are required to fulfil. Clearest example is 'technology forcing' i.e. announcing years in advance what will be the environmental standards for specific products, in order to force producers to innovate (Gerard and Lave, 2005).
- network management, i.e. change the set of actors that determine the course of research and development, create bridging events between various stakeholders to facilitate learning (Parandian, 2012).
- Specifically for innovation in large scale locked in systems, the technological designers are generally just focussing on innovating single artefacts. Systems analysis could make them more aware of the impact of their work on other parts of a system.

2.4_Institutional Change Strategies

From game theory, it is well known that if monopolists have to engage in cooperation, it might be problematic reaching reasonable agreements for both parties. Such a situation often occurs at city level. Hence, it is important that there are actors that might act as intermediary or mediator. Such a mediating role is not a neutral role: a mediator is needed who has a strong interest in achieving environmental results, i.e. in realising the benefits of symbiosis. However, urban authorities cannot fulfil this role: they are too much involved in various interactions with the actors to be trusted as an intermediary (Vernay and Mulder, accepted for publication). Citizen's organisations/NGOs might perhaps play such a role.

Creating technological research and exchange platforms might be important. Local infrastructure is generally defined by locally controlled engineering services. However, this leaves little scope for experiment and research, as the burden is too high for a single municipality. Platforms and (inter-)national support might foster bolder attempts for innovation (Cf. similar strategies in a dispersed industrial sector Moors et al., 1995).

2.5_Un-Lock-in Strategies

Locked in systems are so because of the huge investments in capital, knowledge and relationships that they represent. These assets might lose considerable part of their value by a systems change. Moreover, capital and

knowledge created a level of efficiency that cannot be matched easily by any new technology as such technologies lack optimisation in practice. In general, only after such optimisation processes took place, new technologies are able to match the performance of the established technologies.
This implies that new technologies need protection against the competition of the established technologies, protection based on trust in their potential (Schatzberg, 1994) or financial interests. Societal interests might urge governments to protect technologies that contribute to the environment, public health or safety.

3_Problem analysis sewage systems

In the 19th century there were various methods to deal with sanitation in cities: Cesspools and dumping excrements on the streets or in canals were no longer accepted for public health reasons. Hence various systems emerged: excrement collection in barrels, pneumatic sewer systems and a system that combined excrement removal with other waste- and storm water removal. This last system became 'the' standard sewage system around the turn of the 19th/20th century. (van Zon, 1986) It often combined the functions of preventing local flooding, sanitation and draining groundwater. The 'victory of this sewage system was based on the success of the water-closet (the water caused problems for excrement collection, both by barrel and by pipe) and the imports of growing amounts of guano/Chili saltpetre destroyed the market for fertilizer (Buiter, 2005).
In the course of time the sewage discharges in rivers and canals were no longer accepted as these discharges wiped out aquatic life. Sewage treatment plants were constructed. For these treatment plants, the large quantities of storm water of heavy rain storms were too much; they necessitated discharge of raw sewage. To prevent these sewage discharges, storm water would have to be drained separately. In Europe, this separation is still far from being completed. Hence a considerable part of sewage is still discharged untreated during sanitary sewer overflows. EPA estimated that between 23,000 and 75,000 sanitary sewer overflows occur each year in the United States, resulting in releases of between 3 billion and 10 billion gallons of untreated wastewater (EPA, 2004).
In the treatment plants, more sophisticated forms of treatment were introduced, e.g. for energy efficiency, to generate biogas, and to recover resources. Sewage sludge contained more and more heavy metals and pharmaceuticals. As regulations became more restrictive sewage sludge could hardly be used as fertilizer in agriculture. From the end of the 1990s, sewage sludge was increasingly incinerated, and agricultural use was often terminated in Western Europe because of traces of heavy metals. In fact such decisions were often reinforced by subsequent decisions to drain risky storm water (potentially contaminated with higher levels of heavy metals, e.g. caused by Cupper roofs, galvanised pipes or polluted soil) into the sewage system.
Besides the sewage system, cities created a garbage collection system that emerged from the traditional food scrap collection systems. This system 'exploded' due to the 'explosion' of manufactured food and beverages after WW

II. Various systems to stimulate recycling of materials and resource recovery were developed and food scrap is now generally composted (Block and Vandecasteele, 2011).
Clearly, the sewage system had problems adapting to new requirements by it's' inertia. Whether or not the system can be reordered, by developing symbiotic relations with the garbage system, agriculture and various energy systems is a question that is hardly addressed. 'Lock in' is overwhelmingly present and is reinforced by day to day 'improvements' and investments.

4_A process to open options for change?

In order to contribute to the challenge of climate neutral cities, urban infra-systems need to be improved beyond the day to day marginal innovations that reinforce the pathways that have been chosen in history. This means that infrastructures operators need to be torn out of their 'comfort zone', i.e. they need to step out of the options provided by the locked in technological system and the accompanying culture. Not just the individuals should adopt an open mind set; the organisation should also take measures to foster new ideas and that depart from historic trajectories. In fact infrastructures organisations should be aware that the standards and routines that it developed might be strong barriers to innovation.
Developing a future vision cannot be done without participation of the main stakeholders. Top down planning with its one-dimensional optimisation goals and its technocratic rationality cannot bridge interests and perceptions of main stakeholder groups. Hence it is unable to provide viable options. The method that is proposed here is the participative double scenario method, that results in one or more stakeholder seminars to formulate future visions (Mulder et al., 2012). These seminars might create the foundations for a consensus on a long term development path that breaks away from history. Such a vision should be leading strategic and tactical plans for systems development. This approach might trigger resistance based on the perception that it is impossible to change the systems' basic features. In part, such resistance should be acknowledged, as far as it concerns factors beyond the systems control: factors like magnitude of climate change, demographic change, cultural preferences, interest rates, unemployment rates and military conflict.
The relevant **external** factors for the sanitary need to be fulfilled should be gathered and analysed. They are used to create **external scenarios**, i.e., scenarios that sketch the future environments in which a system might have to function. These scenarios are more or less setting the stage for the actions of the actors. Naturally, the external scenarios are focussed on future issues that are (potentially) of relevance for sanitation. Therefore, in making these scenarios, stakeholder interviews play an important role as they should provide information regarding the relevance of external developments for a sanitation system. In that respect, external scenarios are not neutral or objective: they focus on the external developments that trigger action in the perception of stakeholders.
External scenarios might be presented and discussed at a first stakeholder seminar. The aim of such a seminar is not to establish which external scenario

is most likely to happen, but to establish the reality of these scenarios, and the impacts that courses of events that are sketched in the scenarios will have for sanitation.

Internal scenarios are based upon specific values or interests of stakeholders. They sketch a certain development of the sanitation system. Internal scenarios are based on future studies that identify 'forks' in systems development. The 'forks' that are major determinants of systems development should the starting point for creating internal scenarios, that might be discussed in a second stakeholder seminar (Parandian, 2012).

Such a structured scenario approach turned out to be productive in creating interaction among stakeholders. Its' success partly depends on the combination of a participation approach and a thorough qualitative analysis of future options for development (Mulder et al., 2012). By this combination, the approach might be an interesting tool to contribute to 'unlocking' heavily 'locked in' infrasystems. It might suggest new ideas for symbiotic development that break through bureaucratic walls. It might render a longer term perspective that help in reaching the improvements that urban systems need.

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INTEGRATED APPROACH TO SUSTAINABLE BUILDING DESIGN PROGRAMMING

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Abstract

This paper aims at analysing the relationship between aesthetic and technological aspects in the design process. 'Sustainability' is often a label associated mainly to technological systems aimed at achieving energy efficiency, without considering architectural quality of spaces or environmental and sustainable performances as a holistic approach. Since buildings are working as systems and not as simple sums of elements, this paper proposes an integrated building design methodology, which embeds and merges technological, environmental and esthetical aspects.
To this end, the paper presents the design teaching and research experience carried out with the students of final atelier of the Master of Sustainability, at the Polytechnic of Turin in 2014. In this atelier students were asked to design a building for the Architecture Faculty for The University of Melbourne. During this final atelier, a number of tools were applied throughout the overall design development to helps students in developing projects able to integrate aesthetic, environmental and technological aspects. For instance, one of these tools was the site microclimate matrix, which is a valid instrument for precisely defining master plans organizations, or placing volumetric solutions on sites, following a decision making process based on site-specific functional, technological and environmental aspects. This tool, as well as others that were adopted in the atelier, demonstrated to provide students the ability of developing projects characterised by efficient technical solution and high creative architectural designs.

1_Introduction

It is since the last two decades almost that a vast amount of studies has been carried out on sustainable architecture, both in practice and in the academic context (Stang, Hawthorne 2005; Taylor 2005: Williamson, Radford, Bennetts 2003). Projects categorized as 'sustainable' are often defined either according to the number and type of environmental systems and technologies utilised, as well as their efficiency, rather than their architectural design approach. This tendency seems to reflect both the state of art in both practice and teaching.
The contemporary examples of 'sustainable' architecture show a number of different aesthetic approaches that designers seem to have undertaken. These approaches span from the more literal design solution of 'environmentally aware' buildings, in which the relation with the natural resources was conceived as a design tool; to the more technology oriented approaches, where technologies and environmental artificial systems became expression themselves of an architectural aesthetic (Grosso, Chiesa, Nigra, 2015; Chiesa, Grosso 2015a). In spite the fact that, by-en-large, having an 'environmental awareness' is perceived as an obvious approach to design, and a number of teaching experiences have been carried out (Gürel 2010), the ability of merging technical environmental knowledge to the design process as an integrated design enriching tool seems to be far from being a consolidated approach, at least in the context of the Italian faculties of architecture.

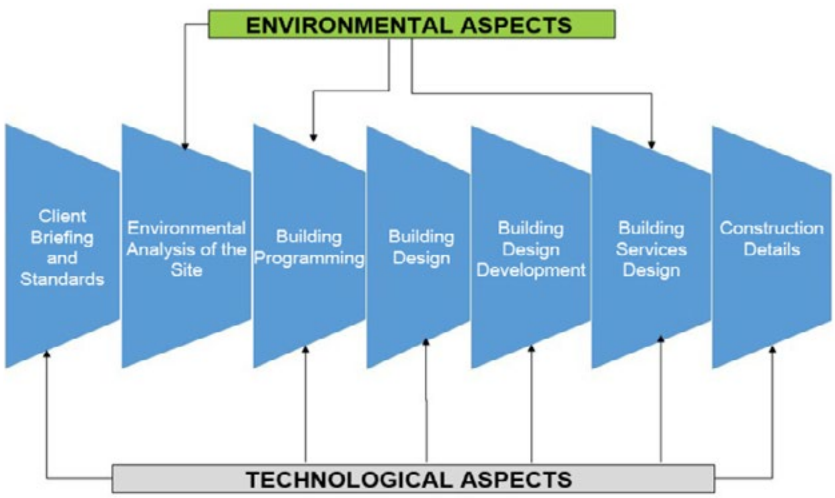
2_The challenge of teaching sustainable architectural design in a changing world

In the final design studio titled Sustainable Design of a Building and its Services (SuDBuS), carried out during the first semester of the academic year 2014-2015 at the Polytechnic of Turin for the Master of Architecture and Sustainability, we faced the challenge of structuring a teaching method that could overcome the existing dichotomy between reaching technical efficiency and developing an aesthetic of sustainability. Specifically, the challenge was answering to the following question: 'Is it possible to teas out aesthetic design alternatives based, not only on the cultural context, normative framework and economic conditions, but also on the result of a set of technical analysis? Is it possible to utilize a 'technique-follow-form' approach today?' The novelty of this approach, at least for the Polytechnic of Turin, was to experiment with the students a design method, which could help them to use of their technical knowledge as a contribution, not only to the creation of fit for purpose projects, but also as a tool that can help define an aesthetic direction in the design decision process, and enrich their compositional skills, which are often left behind the technical priorities in the design studios (Nigra, Grosso, Chiesa 2015).

3_An integrated approach to sustainable design programming – a teaching and design method

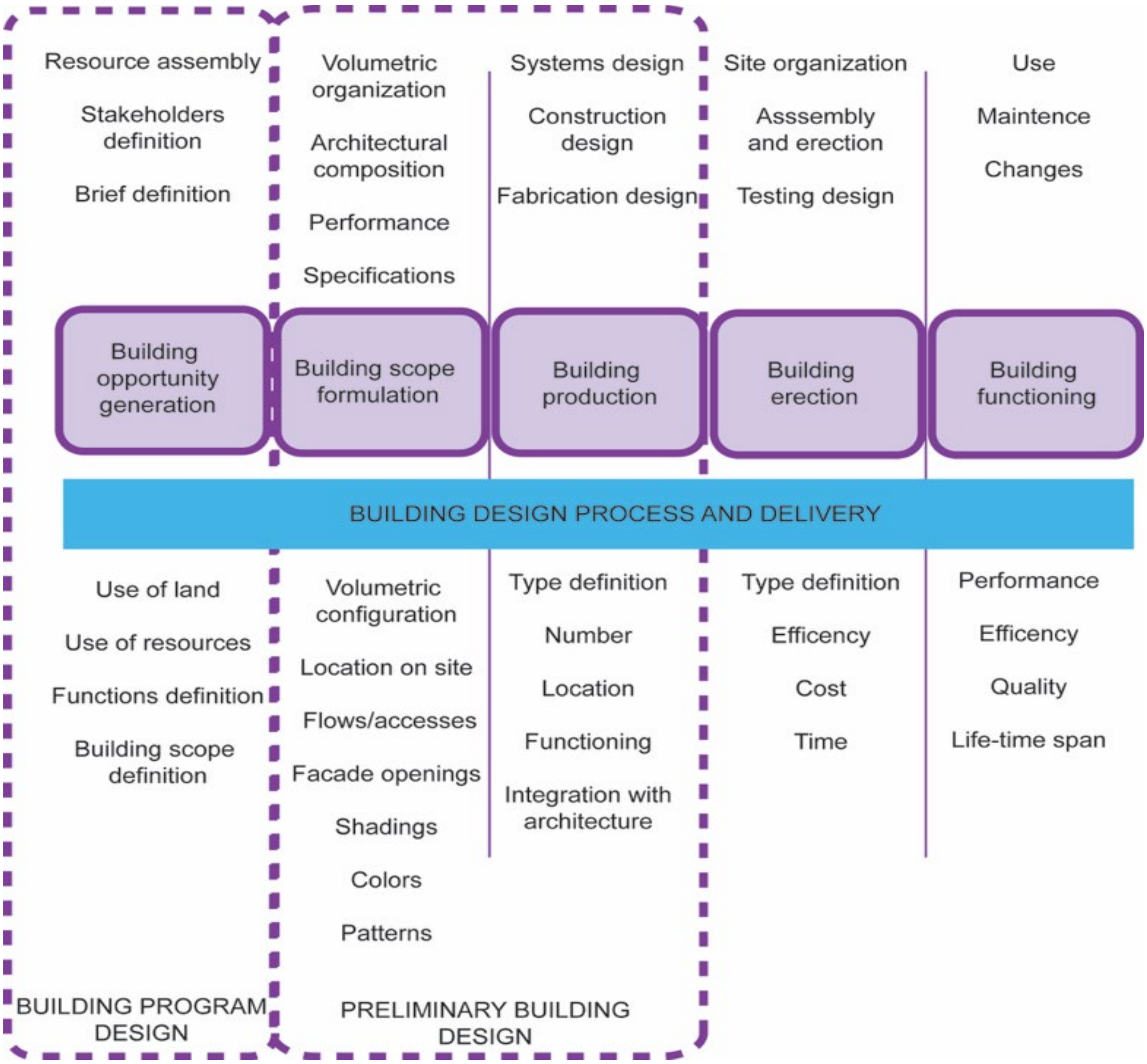
The method utilised was to educate the students to consider environmental technical knowledge as an embedded aspect of the design decision-making process. This was achieve by defining a strategy based on establishing a sequence of the phases characterizing the design process in relation to environmental and technological aspects as shown in figure 1, as well as pointing out the relation between each phase and parameters and tools that students could use both to define effective technological solutions and refined aesthetic proposals, as an integrated objective, as shown in figure 2.

Figure 1. Sequence of the design process according to the sustainability approach (Nigra, Grosso, Chiesa 2015).



This strategy was actualized using a teaching method based on six jointed assignments. These six assignments were: 1) the analysis and design of social and functional sustainability of the spatial organization; 2) microclimatic and wind analysis on the site to assist the volumetric alternative definition and design; 3) technological system research and architectural design definition; 4) façade, envelope, shading and solar systems design definition and analysis; 5) natural and assisted ventilation and evaporation system definition in conjunction to construction system design definition; and 6) construction details definition for the relation between architecture and technological systems. For each of these assignments, the students had to undertake research on existing built projects, understanding systems and design solution, and to design an innovative solution for each part, answering to the following questions: 'How does your design is sustainable? Why is it innovative? How does your design decision seek passives solution to the energy saving issue? What is the aesthetic of sustainability that your design solutions are trying to conceive?' These questions were posed for each assignment as reflection of each phase of a project design development. The significance of this method is that it allowed the students to merge the design process with the technical knowledge and data learned as a system to define creative guidelines to establish a direction for the definition an aesthetic of sustainability, on the top of the ability of proposing project solutions fit for purpose and energetically sustainable (Nigra, Grosso, Chiesa 2015).

Figure 2. The image shows the design parameters that can be informed by the use of microclimatic analysis for each phase of the design process and delivery. Above the blue band, the design process is summarized in its phases and characteristics. Below the blue band the design parameters that be enrich/integrated by the use of the micro-climatic analysis are listed for each phase of the design process (Nigra, Grosso, Chiesa 2015; Grosso, Chiesa, Nigra 2015).



4_The Design Studio Results – A Critical Overview

The outcomes of the applied method in the design studio were the achievement of a number of outstanding projects that that demonstrated the ability of the students to propose design alternatives that respected the technical call for sustainable systems as well as the ability of exploring the aesthetic aspects of sustainability as general design approach. Each assignment produced a sequence of results: the first assignment allowed the understanding during the preliminary phase of the project of the implication of social sustainability in early design decision-making. The second assignment produced the identification of areas on the site that were the most suitable for the required project activities. This was possible by relying on the analysis of the environmental aspects, using the site microclimate matrix in order to localise correctly the building to be designed, considering solar radiation and seasonal prevalent wind flows (Chiesa, Grosso 2015c; Grosso 2011; Brown, Dekay 2001).

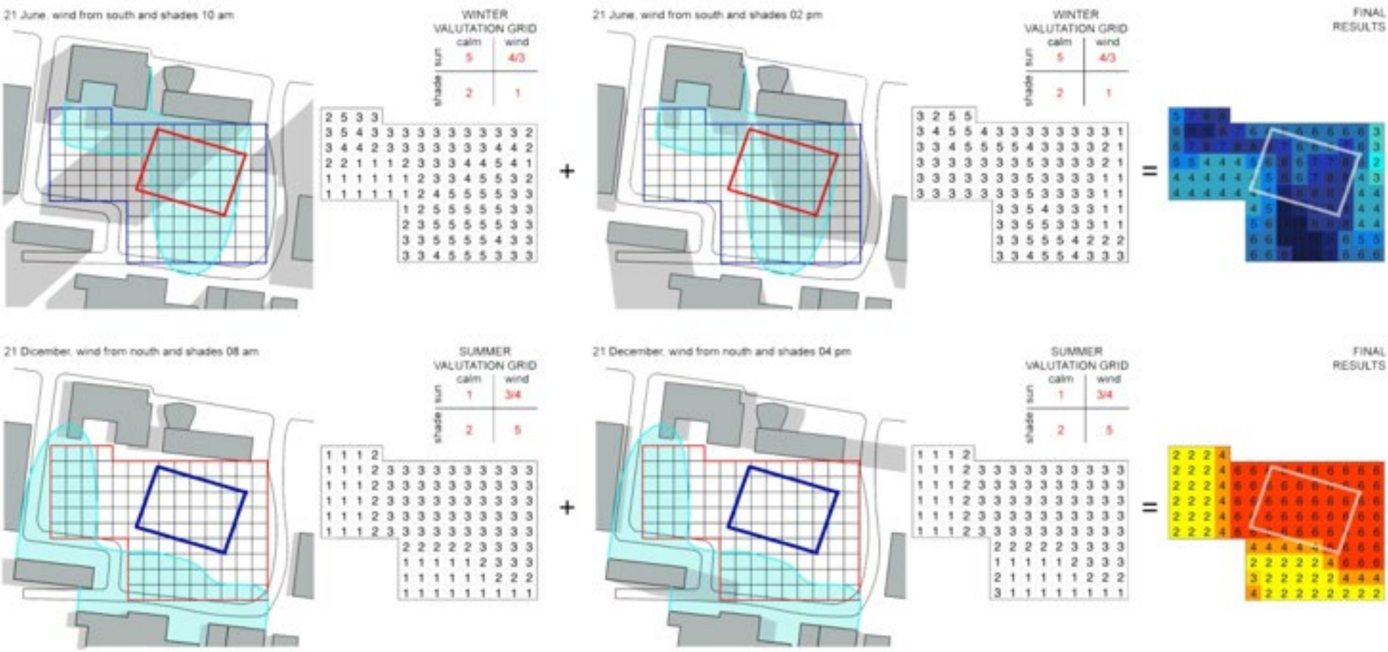


Figure 3. Site microclimate matrix analysis (proposal by Federico Brescia, Giacomo Del Bergiolo, and Silvia Sereno Regis).

On the basis of the data analysed a number of volumetric design alternatives were explored and defined in relation to the spatial distribution in the building. The result of the third assignment was the development of the student's ability to use compositional aspects – such as geometries, shapes, volumetric design, balance, harmony, et cetera – in relation to technological systems used, in such way that students could propose an architectural language that can represent a design language for sustainability. The fourth assignment allowed the students to utilize the wind ad site analysis to define design solutions that can both optimize the site conditions and create spatial design challenges and opportunities, such as the use of atriums, vertical circulation spaces not only as a design opportunity but also as solar chimney, wind tunnels and evaporative towers.

The fifth assignment focused on the use of the climatic analysis to determine the performance and specifications of the main façade components defined in

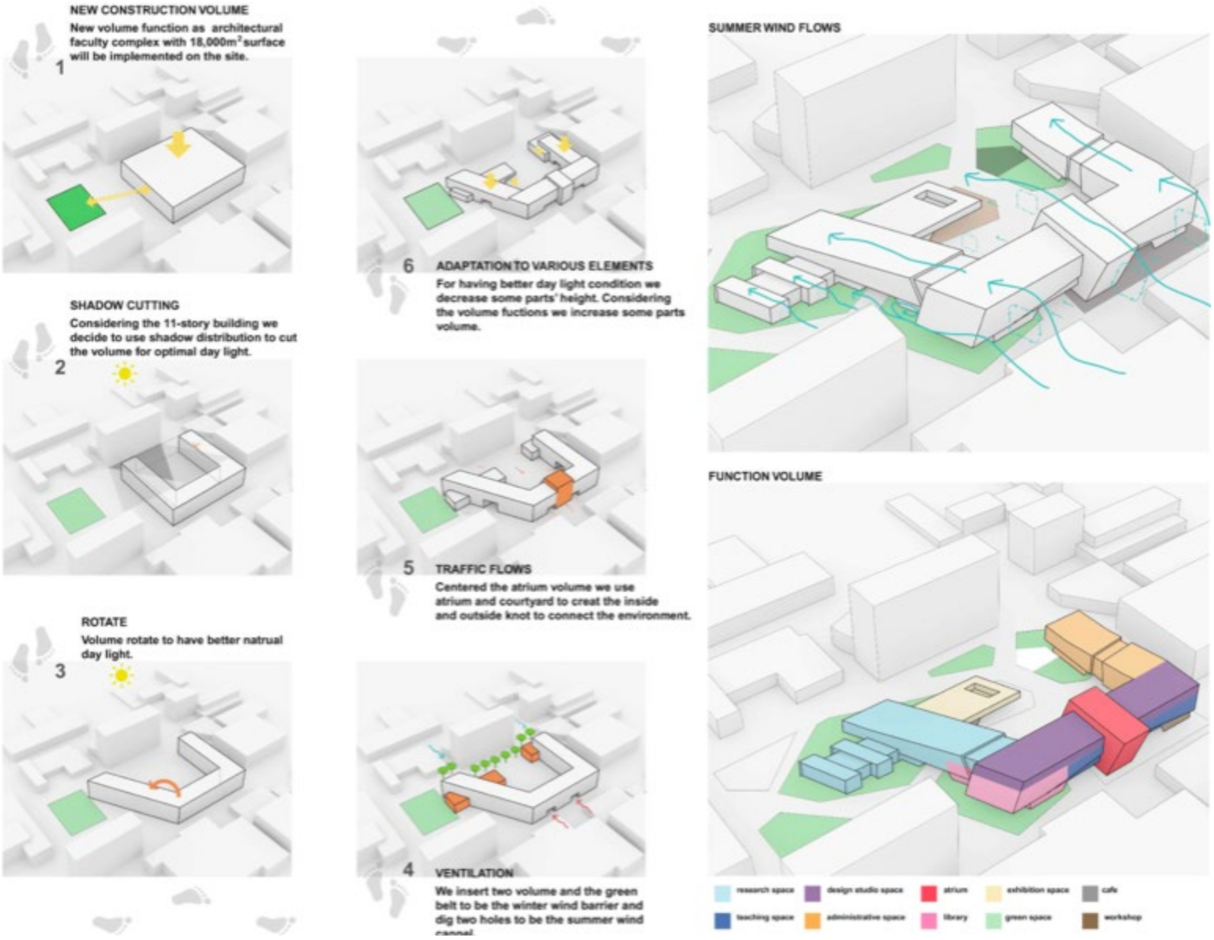


Figure 4. Site microclimate matrix analysis (proposal by Federico Brescia, Giacomo Del Bergiolo, and Silvia Sereno Regis).

the project proposal. Specifically, glazing characteristics, shading devices, and ventilated façade rain screen were selected ad-hoc for each façade, according the exposure and characteristics, elaborated in the micro-climatic analysis.

The sixth and last assignment allowed completing the project by offering the students the opportunity to develop construction details that both became essential for the overall design and architectural language definition, and defining ad-hoc technological solutions that could contribute to the technological sustainability of the project (Nigra, Grosso, Chiesa 2015).

5_Conclusions

The teaching strategy proposed, as well as the design methods utilised shaded light on the importance that environmental building programming and site-climate analysis have in the sustainability approach to buildings design. This is for at least three reasons: 1) having a number of design alternatives directly informed by the environmental context could contribute defining a new architectural language of buildings that could both limit energy consumption and resources depletion, and express the identity of sustainable architecture; 2) using the performance-driven approach since the preliminary design phase, is essential for considering these issues in the design process evaluating different compositional solutions and suggesting possible optimization procedures; and 3) providing the students with a structured design methods that merge technical and aesthetic principle provide them tools and abilities to link and manage complexity within the context of the design process.

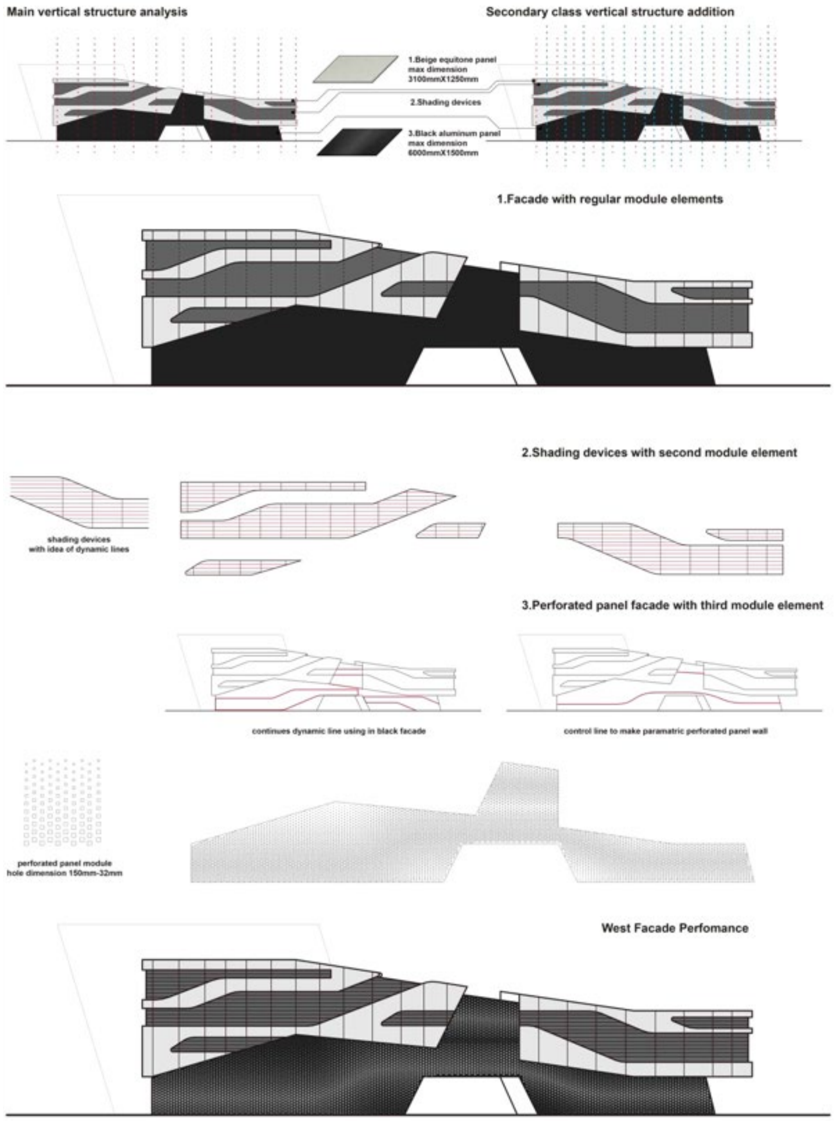


Figure 5. Example of design process to establish modules, patterns and shading devices in a façade design proposed according to the solar analysis on the façade, based on the micro-climatic analysis (study by Mamak P.Tootkaboni, Danial Mohabat Doost, and Xiaochen Song).

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NATURE-BASED URBAN SPACE TRANSFORMATION

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Abstract

*Climate change and climate impacts require in consequence of their anthropogenic causes a changed handling of space and nature. The objective of this research project is to develop a consistent **Integrative Spatial Concept** towards a **Nature-based, Climate-friendly Metropolises 2050**, looking for the best place to implement most efficiently the different measures of **Climate Protection & Adaptation** in the urban and regional context. **The Concept of Interacting Strategies: Nature Development & Urban Restructuring & Energy Transformation** and **The Principles of Connecting & Interacting** within a participative process present a path of spatial sustainability in an ecological, aesthetical and sociopolitical regard. The **Project Nature** is the content base of the **Integrated Spatial Concept Climate Protection & Adaptation** and the objective of all spatial decisions.*
*The special challenge in the realization of spatial strategies for **Climate Protection & Adaptation** and in the success of the transformation is about **The Principles of Connecting, Cooperating & Interacting**. The upcoming tasks will only be accomplished through a common **Societal Act of Solidarity**.*
*Finally the paper questions the transfer of the presented local and regional strategies to the mega-urban level and demands a new **Transdisciplinary Thinking** considering the entire body of a **Megacity**.*

1_Integrative Spatial Concept Climate Protection & Adaptation

Out of the overview of already established concepts in European metropolitan regions and due to the analysis of recent research results in climate change and spatial development, forestry and energy science, space and water management, planning theory and nature philosophy, *The Concept of Interacting Strategies:*
Nature Development & Urban Restructuring & Energy Transformation
on every spatial level & scale: Region & City & District & Quarter & House
is developed, including the essential theoretical basis for the spatial conception (Barbey 2014, 50). Within the conception of *The Integrative Spatial Concept*, the question of the theoretical basis for spatial design and decision-making processes is fundamentally important as well as the definition of priorities and the consideration of spatial effects within the integrative setting of different strategies with the aim to achieve spatial sustainability even in an aesthetical sense (Barbey 2012, 7-9).

1.1_The Project Nature

The content basis of the spatial concept, developed in this research project, is the *Project Nature*. The recognition of the anthropogenic responsibility for global warming and the related climate impact as observed by the IPCC 2007 and 2014 demand the change of the previous form of anthropogenic spatial use (e.g. CO_2 emissions à Atmosphere) in expression (e.g. CO_2 emissions) and development (e.g. land use). Climate change and climate impacts require in consequence of their anthropogenic causes a changed handling of space and nature (Barbey 2014, 50). The content basis of the spatial concept: the *Project Nature*, starts with the basis of the climate change problem: the way of handling nature. The anthropogenic (man-made) causes of climate change besides natural effects of loss of genetic diversity, species and ecosystems results in a major part on the ignorant way to treat nature: nature has to take up a central position within the discourse and the conception of future spatial development perspectives (Barbey 2012, 8).

The *Project Nature* signifies the theoretical background and conceptual basis of the spatial concept and represents within the setting of the *Spatial Strategies Climate Protection & Adaptation*, the strategic objective for the spatial decision. All represented spatial strategies *(Nature Development – Urban Restructuring – Energy Transformation)* are orientated according to the *Project Nature*. In the process of the *Integrated Spatial Conception*, the orientation on the strategic aims of the *Project Nature* is of primary importance for the development of future decisions in dealing with space. The *Project Nature* includes the qualification of ecological potentials, the stabilization of ecosystems and the renewal of existential space substance. The principle of the ruthless use of natural resources (e.g. CO_2 emissions à atmosphere), as the actual cause of the expected damaging effects of anthropogenic climate change, must be turned into the principle of saving, protecting and developing nature. It is the fundamental project to secure the human existence and maintain decent living conditions as well as to sustain actively *Climate Protection & Adaptation*. Climate protection, climate adaptation and energy transformation have to be placed on every spatial level and scale. To develop a *Nature-Orientated, Climate-Friendly Metropolitan Region* the following strategies are essential: *Nature Development & Urban Restructuring & Energy Transformation*. *The Concept of Interacting Strategies: Nature Development & Urban Restructuring & Energy Transformation* has to be developed in the local and regional context on all spatial levels: *Region & City & District & Quarter & House* (compare Barbey 2014, 50).

The *Project Nature* is inspired by the german philosopher Gernot Böhme, who explains in "Die Natur vor uns" ("Nature ahead of us"): The challenge to mitigate climate change and to adapt to its impacts lies ahead of us, as well as "to recognize the state of nature as a common task". "This signifies not only the conservation of nature as something given, but rather the establishing [or development] of nature, even a state of nature, [...] that provides a humane existence in foreseeable future. [...] Nature lies ahead of us: as a challenge", "Nature has become finally [...] a project" (Böhme 2002, 10-26-28).

The process of urban development, which usually begins by the setting of building and Infrastructure into the open space, should now start from the consideration of the natural conditions (invers). Urban development should be orientated, adapted and integrated to the natural, climatic, and geographical conditions of the site in the local and regional context. The globally accepted philosophy of sustainable development does not provide a profound response to the quintessence of the essential question of our century: the human relation to nature. The fundamental philosophical and ethical basis for a changed handling in respect of nature is needed to give a contemporary societal orientation by a forward-looking explication of the human relation towards nature. Essential aspects of "the respecting appreciation in contrast to the annexation or exploitation of nature" are mentioned e.g. by the German philosophers Martin Seel and Jürgen Habermas describes "the immediate aesthetical perception of nature as the essential premise of the potential appreciation of nature" (Habermas 1997,99).

1.2_Aesthetical Principles

With the intention of combining ecological and aesthetical aspects in the spatial qualification of the metropolitan area, aesthetical principles are defined in addition to the mentioned ecological principles of the *Project Nature*, which are in the consideration of the integrative spatial concept of adequate relevant importance. These aesthetical principles orientate the design and the decision making process of the spatial setting to a substantial aesthetic level and represent basically the spatial principles of *Concentration & Protection* as well as the paradigm of the 21st century towards a sustainable development related to a changed handling of space and nature: *Ressource Saving & Energy Efficiency* (Barbey 2014, 50).

2_Nature-orientated, Climate-friendly Metropolitan Region 2050

Applying this content basis and reflecting the particular site-specific consideration such as natural geographical and urban spatial, climatic and energetic parameters, the *Integrative Spatial Concept* is developed for the metropolitan region Rhine-Neckar with a view to achieving *Nature-Orientated, Climate-Friendly Metropolitan Region Rhine-Neckar 2050* (Fig. 1). This research project is an exemplary attempt to develop a consistent spatial concept relating to the Metropolitan Region Rhine-Neckar (5.640 km^2, 2,4 Mio. inhabitants, the warmest region in the south-west of Germany with projections of increasing heat, rain and flood events, dense polycentric urban structure of cities as Heidelberg, Mannheim and Ludwigshafen and villages in a diverse open space and landscape structure, important universities and highly industrialized urban poles situated in a beautiful Rhine-valley landscape framed by hilly Palatinate and Odenwald forests, confluence of Rhine and Neckar) and the city of Mannheim (145 km^2, 300.000 inhabitants) looking for the best place to implement most efficiently the different measures. As an informal planning instrument, the *Integrative Spatial Concept* could be the basis for discussions and civic participation with the intention to support the spatial realization of the climate protective and adaptive transformation (compare Barbey 2014, 50-51).

The design and the decision making process of the spatial concept is furthermore based on the results of different regional studies and some interesting aspects in existing concepts. Combining the knowledge and database of transdisciplinary regional research (climatic, demographic and spatial development, forestry and energy science, space and water management, planning theory and nature philosophy) as well as discussing and verifying the most efficient position (even in an aesthetical sense) for every measure in the local and regional context (compare Barbey 2012, 7-8-9), the spatial concept shows, which appropriate strategies for climate protection and adaptation should be placed where, (at which place) such measures could be concentrated to advance *Climate Protection & Adaptation* and to realize the processes

Nature Development 1	Forest transformation & forest development	Climate Adaptation & Protection
Nature Development 2	Protection & development of open space	Climate Adaptation
Nature Development 3	Development of inner-city green space	Climate Adaptation
Nature Development 4	Room for the river	Climate Adaptation
Nature Development 5	Groundwater protection	Climate Adaptation
Nature Development 6	Organic farming	Climate Protection & Adaptation
Urban Restructuring 1	Development of the inner-city	Climate Protection & Adaptation
Urban Restructuring 2	Development of the existing building stock	Climate Protection & Adaptation
Urban Restructuring 3	Energetic urban renewal	Climate Protection
Urban Restructuring 4	Climate-friendly and water-sensitive urban development	Climate Protection & Adaptation
Energy Transformation 1	Spatial concentration of wind turbines	Climate Protection
Energy Transformation 2	Urban concentrated use of photovoltaic	Climate Protection
Energy Transformation 3	Use of regional potentialsà geothermal energy	Climate Protection
Energy Transformation 4	Use of regional and local potentials à bioenergy	Climate Protection
Energy Transformation 5	Use of regional potentials à hydraulic energy	Climate Protection
Energy Transformation 6	Expansion of public transport & climate neutral mobility	Climate Protection
Energy Transformation 7	Expansion of the electricity network and energy storage	Climate Protection

Table 2. Spatial Strategies & Principles and Synergies Climate Protection & Adaptation.

Nature Development & Urban Restructuring & Energy Transformation actually on a grand scale. The catalogue of strategies, which could be considered as a kind of *Roadmap 2050 Climate Protection & Adaptation* for the Metropolitan Region Rhine-Neckar, is considered to be forward-looking. (compare Barbey 2014, 51)

3_Nature-Orientated, Climate-Friendly Metropolitan Region 2050 Roadmap 2050 - Recommendations for Action in Metropolitan Regions

In the sum of the interactive strategies *Nature Development & Urban Restructuring & Energy Transformation*, for which the effects can be approximately valued on the results of scientific reports, 50% energy can be saved, 70% CO_2 emissions can be reduced and 100% of the electricity demand can be covered by renewable energies in 2050. The *Integrative Spatial Concept* shows the potentials of *Climate Protection & Adaptation*, the focus of strategies and the combination of measures and their interacting effects and synergies. It represents concentrated activity of priority action areas as well as challenges of local and regional interaction. It locates the objectives *Climate Protection & Adaptation* and formulates the idea *Nature-Orientated, Climate-Friendly Metropolitan Region 2050* as a common task for local stakeholders and the metropolitan society with a concrete time frame. In the general view of the integrative spatial concept a self-evident picture is developed within the implementation of the different measures. The conception of the spatial setting of the strategies in the plan seem partly self-evident, which is caused by the exact consideration of the site-specific geographical reference and

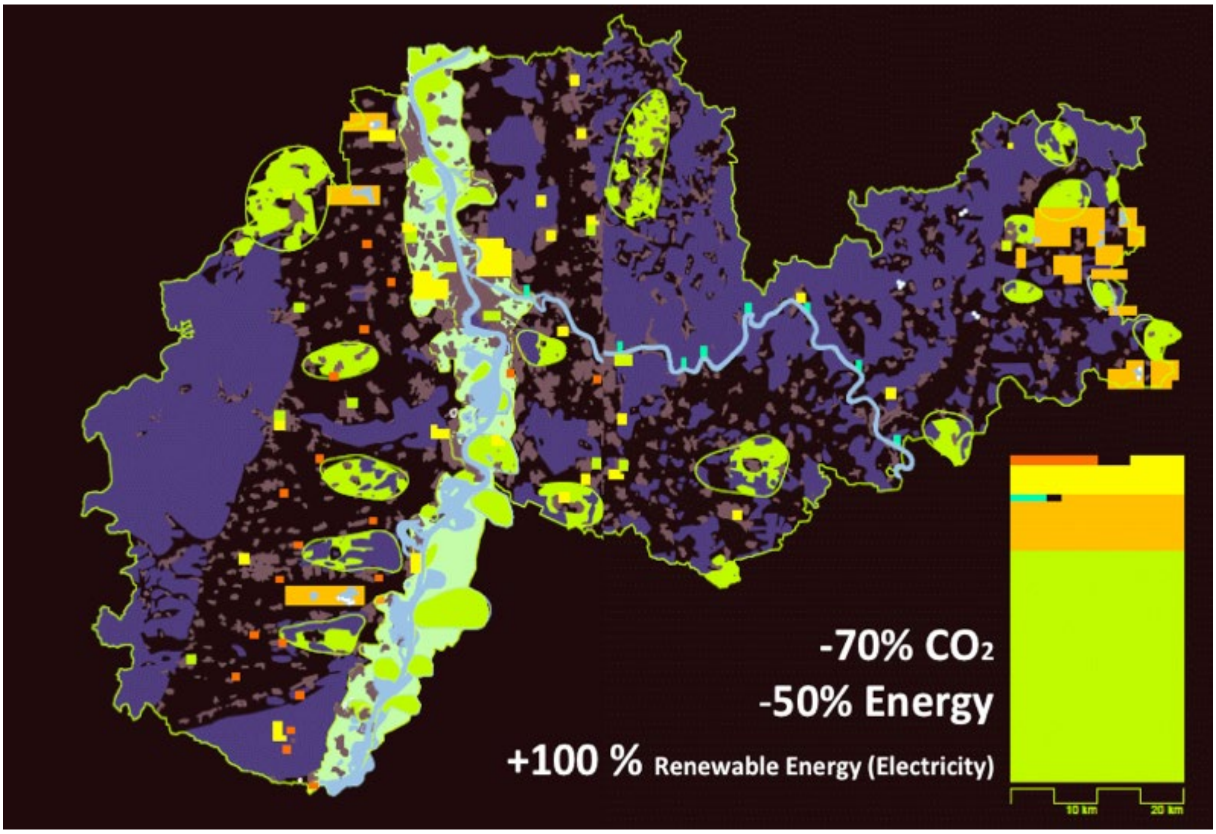

Figure 1. Nature-Orientated, Climate-Friendly Metropolitan Region 2050.

Legend:
green: new forests
orange: wind energy
yellow: photovoltaics
turquois: hydroenergy
red: geothermal energy.

about the *Where* and *How* of the integration of measures in the spatial context. The spatial effects of the strategies serve besides *Climate Protection & Adaptation* to substantial improvement of ecologic and spatial aesthetic qualities (compare Barbey 2014, 51).

The strategies are located within the conceptual designing and decision-making process in Figures 1 and 2 according to the analyzed specific characteristics and abilities of the particular spaces and describe the spatial potentials for *Climate Protection & Adaptation* in metropolises and metropolitan regions. The overall view of the integrative concept shows the synergetic principle of the interaction of *Nature Development & Urban Restructuring & Energy Transformation* for *Climate Protection & Adaptation*. This approach is explicitly oriented to the spatial possibilities and geographical as well as natural conditions of the sites and the existing urban building stock. In the setting of the measures the spatial aesthetic principles mentioned above, have been applied under the title: *Concentration & Protection* or rather keeping free, which will be explained here with a few examples:

The principle of emphasizing the natural characteristics: The Rhine valley is emphasized as landscape-park with new forests and retention areas. The Palatine and the Odenwald forests are kept free of energy-related interventions. They are protected and presented as specific natural treasure of the metropolitan region.

The principle of integration in the environmental context: New forests are integrated in the sparsely wooded Rhine valley, in the Kraichgau, in the landscape along the Rhine and as urban forest in the cities and additional forest in the Odenwald forest.

The principle of spatial concentration of structural, natural and energy-technical interventions as well as the continuance of existing potentials: Five wind parks are concentrated and connected to existing wind parks and existing networks. According to the priority positioning of the strategy *Nature Development*, the construction of wind energy plants in the Palatine forest and Odenwald forest is a taboo – environmental and landscape protection play the major role in decision-making.

The spatial characterized choice of location (choice of the adequate location, by weighing up climate protection, climate adaptation and spatial aesthetics): Industrial and commercial areas have the greatest potentials for generating solar power compared to other urban space typologies, because of their large roof structures, as well as façade surfaces. In these areas the energy yield is the highest. For this as well as for aesthetic and practicable reasons (simplified realization of civic power plants), an urban concentrated use of photovoltaics is recommended (protection of cropland for organic farming and forest development) (Barbey 2014, 51-52).

4_Nature-Orientated, Climate-Friendly Metropolis 2050 Roadmap 2050 - Recommendations for Action in Metropolises

The regional strategies are transferred to the local level and the concept *Nature-Orientated, Climate-Friendly Metropolis Mannheim 2050* (Fig. 2) is developed to show in addition to the regional (Fig. 1), the urban spatial potentials of *Climate Protection & Adaptation*. Only in the interaction of integrated regional and local urban strategies the spatial ambition: *Nature-Orientated, Climate-Friendly Metropolitan Region 2050* could be realized (Barbey 2014, 52).

The following recommended aspects of action are derived from the conception *Nature-Orientated, Climate-Friendly Metropolis Mannheim 2050* (Fig. 2):

> For a climate responsible urban development it is reasonable,

1. to define a superior green space system as basis for future urban development and
2. to develop every urban district according to the concept of the interactive strategies *Nature Development & Urban Restructuring & Energy Transformation*.
3. On the citywide level the concept of the Nature-Orientated, Climate-Friendly Metropolis 2050 then results from the principle of interaction between the superior green space structure and the climate-friendly developed urban districts and quarters.

> The open green space of the city is the superior green space system, which connects the city with the landscape and the urban quarters with each other. The regional strategies *Nature Development & Urban Restructuring & Energy Transformation*, are transferred on the local level in the city and in every urban district.

> The urban districts, which appear partly fragmented, will be supplemented structurally (inner-city development), the existing building stock will be renovated energetically, energy clusters and district heating networks will be established, the energetic potentials will be developed and used

by public participation in common power stations (in industrial and commercial areas). Every urban quarter gets a resilient, spatial high qualitative green system with green space for shadow and fresh air in the direct surrounding.

- The concepts *Green Metropolis*, *Inner City Development* as well as *Energy Efficiency & Energy Gain* describe in their summation the process of urban transformation for the city of Mannheim.
- Climate protection and climate adaptation have to be developed in the city and in the quarter according to the potentials of the particular place.
- The concepts *Green Metropolis*, *Inner City Development* as well as *Energy Efficiency & Energy Gain* have to interact on a spatial level in the quarters and in the sum of the quarters in the city.
- The urban quarter seems to be the adequate and effective cell of climate conscious and water-sensitive urban development in the overall urban context towards a *Nature-Orientated, Climate-Friendly Metropolis 2050*, also because of its manageable dimension. The development of district-related concepts of interactive strategies provides the opportunity to develop district-specific and qualifying solutions and beyond that the activation of a local stakeholders network (compare Barbey 2014, 52).

4.1_Summary of the recommended action for the spatial development of the metropolis

The open green space as starting point of urban planning

Establishment of a continuous green space system

(resilient spatial structure and spatial connecting of the different quarters of the city)

The individual urban districts are the objects on the ground of the natural green space

Developing the districts as functional clusters climate protection & climate adaptation,

Interaction of the concepts *Green Metropolis & Inner City Development & Energy Efficiency & Energy Gain*, which in total represent a *Nature-Orientated, Climate-Friendly & Water-Sensitive Metropolis 2050*.

The nature-orientated, climate-friendly and water-sensitive urban development

includes in every quarter: *Concept of Green Metropolis & Concept of Inner Urban Development & Concept of Energy Efficiency & Energy Gain* **with the aims of the development of spatial qualities and spatial sustainability in the city** (Barbey 2014, 52-53).

5_Conditions to Realize Climate Protection & Adaptation

The Concept of Interacting Strategies

The Concept of Interacting Strategies Climate Protection & Adaptation: Nature Development & Urban Restructuring & Energy Transformation and *The Principles of Connecting, Cooperating & Interacting* must be developed

on the essential level of preparation:
Climate Policy – Spatial Concept – Climate Economics
on the level of realization:
City – Energy Provider – Entrepreneur – Citizen – Planner – University
and on the spatial level:
Quarter & City, Metropolis & Metropolitan Region, Metropolitan Regions & Nations, Metropolitan Regions Global
Metropolises and Metropolitan regions are important global players towards *Climate Protection & Adaptation*.
Only in the global network of metropolises and metropolitan regions and their interacting spatial strategies, the essential effects of climate protection and climate adaptation can be developed on a global level and the aims of *Climate Protection & Adaptation* can be reached (compare Barbey 2012, 340-341).

Political commitment Climate Protection & Adaptation

First experiences in the implementation of the mentioned international examples point to the essential role of political commitments for the spatial implementation of the formulated political aims. Political commitments have to be represented in spatial concepts with a concrete time horizon of realization. They have to correspond to the space and its specific conditions (Barbey 2014, 53).

The Principles of Connecting, Cooperating & Interacting

The special challenge in the realization of spatial strategies for *Climate Protection & Adaptation* and in the success of the transformation, caused by climate change and energy transformation, is about *The Principles of Connecting, Cooperating & Interacting*. The upcoming tasks will only be accomplished through a common *Societal Act of Solidarity*. The *Concept of Interacting Strategies Climate Protection & Adaptation* on the societal level points to the potential to realize appropriate strategies as well as to achieve an appropriate impact of *Climate Protection & Adaptation* by the societal network of a cooperating citizens and stakeholders (Barbey 2014, 53).

The Interaction of political commitment and civic participation is a key condition to realize *Climate Protection & Adaptation*. Politicians, citizens, entrepreneurs, planners, architects, engineers, economists, sociologists and artists have to work together to create intelligent solutions for a sustainable urban development. The consistent *Integrative Spatial Concept Climate Protection & Adaptation* could be the basis for discussions and civic participation with the intension to support the spatial realization of the climate protective and adaptive transformation.

6_Chances

Nature Development – Urban Restructuring – Energy Transformation
are qualification processes, which can lead to an improvement of existing qualities.
Nature Development > Chance of ecological (+ aesthetical) Qualification
Urban Restructuring > Chance of aesthetical (+ ecological) Qualification
Energy Transformation > Chance of sociopolitical (+ ecological) Renewal

In connection and interaction of these strategies a development path of sustainable spatial development will be developed in an ecological, aesthetical and sociopolitical regard (Barbey 2014, 53).

The presented *Integrative Spatial Concept* sets an example of a possible path towards a *Nature-based, Climate-friendly Metropolitan Region 2050*. Every mentioned *Spatial Strategy & Principle for Climate Protection & Adaptation* is generally applicable in every City and Metropolitan Region in Europe and beyond. In addition the described *Process of Conception* is generally transferrable to every City and Metropolitain Region in the world, always supposing that the selection, the dimension and the combination of strategies are well adapted to the site-specific spatial, energetical, climatical and cultural conditions.

7_Nature-orientated, Climate-friendly Megacity 2050?

By focusing *Spatial Strategies Climate Protection & Adaptation* on the level of the *Metropolitan Region* and the *Metropolis*, the intention is now to question the *Megacities* development. The open question is, will the transfer of the presented *Spatial Strategies Climate Protection & Adaptation* to the level of Megacities make any sense or do we need a complete new spatial thinking because of different conditions in terms of informal planning and building processes? The complexity of global processes and major trends of informal, not governed, spatial development calls into question the capacity of planning activities in general. The overview of existing social and ecological problems in *Megacities* demands the creation of new ideas and new planning methods. The responsible view towards a *Nature-Orientated, Climate-Friendly Megacity* challenges an *Integrative, Transdisciplinary Thinking* to figure out possible solutions at the local mega-urban level, considering the entire body of a *Megacity*.

Actually nobody knows yet, even not the experts of the World-Bank, European Commission and UN how to deal with the challenges facing *Climate Protection & Adaptation* on the mega-urban level. The open questions concerning the sustainable development of *Megacities* require a change of usual spatial thinking- and planning models, a profound research of local conditions and potentials and an intense collaboration with local actors and citizens. Transdisciplinary research in sustainable urban development is required, combining global spatial, sociocultural, economical, ecological and political-institutional knowledge.

7.2_Climate Protection & Climate Adaptation

Megacities contribute to global climate change by concentrating large parts of the urban population, major shares of their countries' economic and industrial activities as well as the consumption of food, water, natural resources, land and energy as a major source of anthropogenic greenhouse gas emissions. Covering only a small percentage of the earth's surface (current coverage 2%), cities are responsible for around 60-80% of global energy consumption and for approximately 75% of global greenhouse gas emissions (UNEP 2011). Projections expect 80–90% of future population growth in *Megacities*, especially in the agglomerations of the global South, and the increasing

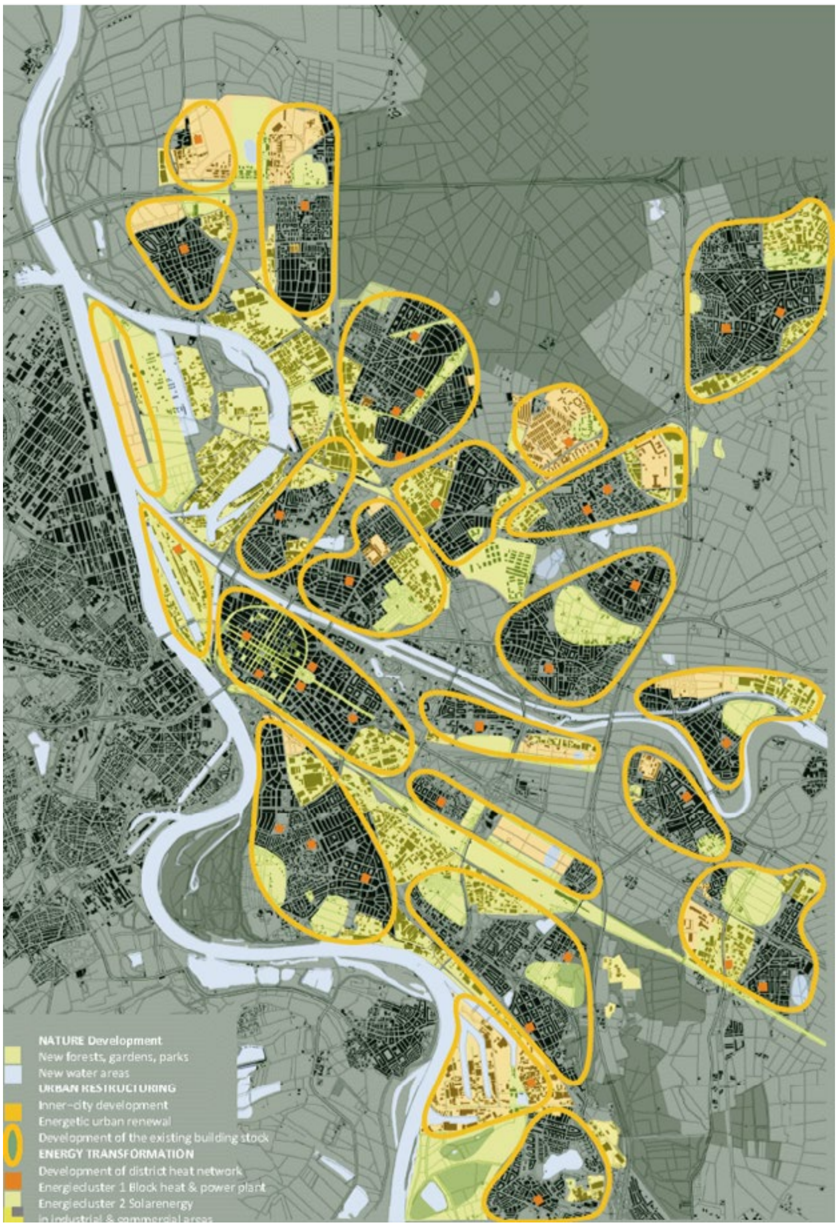

Figure 2. Nature-Orientated, Climate-Friendly Metropolis 2050.

Legend:

Nature Development:
green: new forests, gardens, parks, blue: new water areas;

Urban Restructuring:
orange: inner-city development, energetic urban renewal, orange line: Development of the existing building stock

Energy Transformation:
Development of district heat network,
red: Energy cluster 1 Block heat & power plant,
yellow: Energy cluster 2 Solar energy in industrial & commercial areas.

contribution of *Megacities*' greenhouse gas emissions to the increase of total greenhouse gas concentrations as a consequence (Bernd and Heinrichs 2014, 12). Cities in so-called 'developing countries' will be responsible for about 80% of the increases in the global annual energy consumption between 2006 and 2030 (UN-Habitat 2011, 26).

While *Megacities* are significantly contributing to, they are also affected by global climate change. Often located along the coast, close to rising sea levels, or in arid areas, *Megacities* have to deal with its impacts and sometimes devastating consequences (Pahl-Weber et al. 2014, 5). Beyond that megacities are not only exposed to climate change risks but also concentrate large numbers of the most vulnerable parts of the population, living in slums under impoverished, overcrowded and insecure living conditions. The strongest effects of climate change and the highest level of vulnerability are expected in Africa and parts of Asia, where the process of urbanization takes place at high-speed (Bernd and Heinrichs 2014, 12). *Megacities* must take *Climate*

Protection & Adaptation action is required to reduce greenhouse gas emissions by increasing energy and resource efficiency, implementing renewable energy systems as well as developing resilient spatial structures.

The fundamental question of all mega-urban development is the *Project Nature*, i. e. the consideration of the natural conditions. The urban development and restructuring of *Megacities* must be orientated, adapted and integrated to the natural, climatic, and geographical conditions of the site in the local and regional context. The essential question of our century: *The Human Relation to Nature* is drastically present facing existing and future societal and environmental phenomena of mega-urban development worldwide. A changed handling in respect of *Nature & Humanity* is needed to give liveable perspectives on a global level.

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GROWING OR STEADY CITIES? ACCOUNTING THE URBAN METABOLISM OF ITALIAN CITIES

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urban metabolism
climate change

Abstract

This contribution aims to identify a theoretical model to develop tools for reducing cities GHG emissions. Cities' urban metabolism is responsible for at least 70% of total GHG emissions. To reach future reductions of GHG emissions we need a tool to account urban metabolism. We suggest to use a consumption-based model instead of conventional production-based models of accounting. In this survey we used data coming from National Italian Institute for Statistics covering tha length of time from 2002 to 2010. Data collected and elaborated show that the urban metabolism of the Italian cities is, at the aggregate level, stable in time. It means that, as it has been revealed by many studies, western urban systems have reached saturated consumption patterns. Expecting or forecasting future strong increasing levels of consumption will be difficult.

1_Growing and consuming cities

Global urban growth implies increasing consumption. The specular aspect of city as a growing machine is that of a "spatial unit of collective consumption" (Castells, 1977: orig. ed. 1972). Urban system functions are arranged in huge areas of activities aimed at reproducing the system itself. Sociologists have mainly investigated the 'urban symbolic' (the meanings emitted by socially produced spatial forms) of the cultural arena provided by "urbanism" (Wirth, 1938). However, to perform these cultural or political functions cities must exchange matter and energy with the environment. It means that urban reproduction might be unpacked into three great areas of activities: production, consumption and exchange, each of which corresponds to different elements in the urban system (such as factories and offices, housing and recreational facilities, and means of transportation respectively). Yet urban systems – principally Western cities – are less and less places of production of goods since capitalist production is increasingly organized on a global scale. Different stages in the production process are located at different countries or continents, factories in one town are administered from offices in another, the old urban production has been dislocated either in near places and around the world. It follows from this that the global system of exchange has grown over the time building up huge networks of transports and huge hubs of exchange usually situated outside urban boundaries. For many cities it has meant that their main function begun to be focused in the process of consumption and reproduction of their inhabitants.

Consumption performs a number of societal functions, as, for example, the necessary end point of commodity production or the human agents reproduction. In other words, it is only by consuming socially necessary use values (housing, food, energy, water, leisure facilities, etc.) that agents are able to reproduce their capability to engage in activities and practices. This specific function of reproduction of the urban system is performed on a daily basis and on a generational basis (through the production of new generations of agents to replace the existing one), and it entails both simple reproduction (recreation of daily capacities) and extended reproduction (development of new capacities to perform social practices). The means whereby such

reproduction is realized are the means of consumption – housing, shops, hospitals, schools, leisure facilities. Unlike the means of production, these means of consumption are specific to urban spatial units. The result is that the means of consumption have not only become concentrated within specific spatial units, but have also become more and more collectivized, and it is this growing significance of the collective provision of the means of consumption what makes the urban system the fittest locus for consumption giving rise to increased concentration and centralization.
Urban systems as described by Castells and Molotch (1976) at least forty years ago seem to be still very valuable. At global level, cities and large urban areas are already where most of the world's population lives. By 2030, an estimated 59% of the world's population will live in urban areas, with developed countries as the most urbanized at 81%. Meanwhile, in developing countries the average is projected to be around 55% by 2030. The rise of urban population is among the core causes of great environmental impact of cities. Environmental crisis involving climate change, loss of bio-diversity, nitrogen cycle damage, and many more, is opening new and more sustainable strategies for governing urban metabolism. Urban areas are hot spots that drive environmental change at multiple scales. According to the UN-HABITAT's Cities and Climate Change global report on Human settlements 2011, the world's cities are responsible for 75% of global energy consumption and up to 70% of harmful GHG greenhouse gases, while occupying just 2% of its land and being home to just half of the global population, clearly indicating the carbon-dependence of the urban economy. At the same time, material demand of consumption and production alters land use, biodiversity, ecosystem services, local and global hydrosystems, and urban waste disposal so affecting local to global biogeochemical cycles and climate (Grimm et al., 2008). Yet another crucial aspect must be underlined. It refers to the fact that different paths of evolution are featuring Western and non-Western cities. If these latter are becoming the place of global production the former are becoming the site of global consumption, as Max Weber pinpointed years ago.

2_Addressing Urban Metabolism

If we admit that cities are consumption growth machines, we are thrust to define them as complex systems of urban metabolism, whereby metabolism is more than an input/output mechanism. Urban metabolism refers to the metabolic processes by which cities transform incoming raw materials, biomass, energy, and water into physical structures, built environment, technical devices, food, waste (Decker et al., 2000) which support a huge amount of reproductive activities performed by their inhabitants. Urban Metabolism (UM) is a multi-disciplinary and integrated platform that examines material and energy flows in cities as complex systems as they are shaped by various social, economic and environmental forces. The adoption of this concept has fostered new images of what the city is and how material and non-material flows make possible the production and reproduction of the city, both as a biophysical and as a socio-economic entity (Swyngedouw, 2006). The Urban Unit at the World Bank released in 2010 a high profile report called Eco2Cities

(Suzuki et al., 2010), which advocated urban metabolism understandings of the city in sustainable urban development. Urban metabolism can be seen under three perspectives: functional, where city is considered as an organism based on input/output mechanism (*physiology*) that exchange energy and matter with its environment (focus is paid on maintaining a balance); analogical, where city is looked from a *morphological* point of view and where attention is paid on its internal organisation; *political*, where city is looked from is regulatory political economy based on social and economic tensions and conflicts (Rapoport, 2011).
The bio-physical or physiological approach to studying and quantifying urban material and energy flows and stocks is the predominant interpretation of urban metabolism today (see e.g. Gandy, 2004; The BRIDGE project, 2008; Suzuki et al., 2010;). Such studies generally focus on quantifying the flows of particular materials or energy in an urban system (Baccini, 1997; Brunner, 2008; Barles, 2010;). Many scholars also claim that urban metabolism studies can be a tool both for identifying environmental problems and for designing more efficient urban planning policies (Barles, 2010; Niza et al., 2009). In general, the metabolism model looks at links between urban and environmental quality, as well as among urban drivers, patterns of consumption and metabolic flows. In few words, urban metabolism is a set of processes taking place in the urban system involving transformation and transportation of matter and energy in such a way that the systems work as an organized entity.
This paper attempts in the same wake to depict the metabolic profile of cities through the analysis of quantitative data from national statistics, being a first attempt to evaluate and compare urban metabolism among Italian cities. Here, we have chosen the consumption based approach to evaluate resources consumed by urban dwellers. We did not translate resources' consumption in CO_2 equivalent emissions, but it is clear our attempt to foster a contribution to evaluate the evolution of urban impact on resources consumption and indirectly on climate change. Secondly, we chose to investigate aggregate individual consumption leaving out from data the urban drivers of consumption such as public buildings or public services provision and indirect energy consumption such as food and drink among others. It means that we covered around the 50% of the total urban system consumption.

3_Accounting the metabolism of the Italian provincial capitals

This section contains the description of the steps we moved in the direction of trying to approach the urban metabolism description by starting from a distance that is bigger than the usual. We decided to use low-resolution data on the per-capita consumption of some resources/services in order to compare some metabolic aspects of a larger number of cities: of more than 100 Italian towns, all of them being provincial capitals. We wondered whether it was possible to isolate some features of Italian towns that could explain, at least partially, the reasons of the levels of consumption that they show, and that could explain if they are facing some common or peculiar metabolic paths or trajectories. We were moved by the idea that only by first using such a distant perspective it will become clearer how to approach it more deeply and which

[1] In the following of this paper, electricity and natural gas consumption will sometimes be fused in the indicator "kWh". The transformation of natural gas in kWh is based on a coefficient of 10.5 kWh = 1 cubic meter of natural gas. Towns without a natural gas distribution network are not taken into consideration.

kind of indicators would be useful in addressing the urban metabolism calculation more properly. That is why we did not calculate the aggregated total levels of consumption for provincial capitals, and that is why the statistics that will be shown in the following paragraphs are not weighted for towns' population.

3.1_The data we used

Since year 2000 ISTAT, the National Italian Institute for Statistics, has been annually producing the Urban Environmental Indicators for the provincial capitals. Italy is currently divided into 20 regions and 110 provinces. It is only during the last few years that some new provinces were created having, some of them, more than one capital. However, due to lack of data for the most recently created provincial capitals, we took into consideration the provinces (and their capitals) as they were before the latest changes occurred in 2009, meaning that 107 provinces and 111 provincial capitals compose the sample. Our paper considered only per capita/consumption accounted in terms of physical quantity. It is in line with Eurostat's Urban Audit data sources, which provides relevant statistical data for over 300 cities in Europe. Such data include share of car journeys among all work journeys, number of registered cars per 1000 inhabitants, number of public transport stops per square kilometre, and solid waste production per inhabitant. We divided the variables we used into three main categories, according to the role we gave to them in our analysis, as follows:

Consumption / Dependent variables	
Water:	per-capita consumption for domestic uses (liters per day)
Natural gas:	per-capita consumption for heating and other domestic uses (cubic meters per year)
Electricity:	per-capita consumption for domestic uses (kWh per year)[1]
Wastes:	per-capita production (kg per year)
Motorization rate:	number of cars (per 1,000 inhabitants)
Demand for LPT:	per-capita demand for Local Public Transport (passenger trips per year)
Offer of LPT:	per-capita offer of Local Public Transport (km-seats per year)
Socio-demographic / Primary explanatory variables	
Population density:	inhabitants (per square km)
Ageing Index:	ratio - people aged ≥65 / people aged <15
Income:	per-capita at current prices
Family size:	average number of family components
Degree-days:	they represent the sum, extended to all days of a conventional heating period, of only the positive differences between the daily indoor temperature, fixed by convention at 20°C, and the daily average outdoor temperature (Law n°412, 26th August 1993)
Secondary explanatory variables	
Present population:	not resident people that was present in town during the 2001 national census, as percent of the total resident population
Commuters:	balance between outbound and inbound commuters, as percent of the total resident population
Tourist Attraction Index:	number of nights spent in the receptive structures of the town, per inhabitant
Additional population:	commuters, city users, present but not resident people, tourists, as percent of the total resident population

For all variables related to consumption, we took into consideration data coming from the two years 2002 and 2011, in order to cover the two extremes of an entire decade.

3.2_Characteristics of the sample: socio-demographic structure and levels of consumption

By taking into consideration provincial capitals, we are concentrating our attention on peculiar towns, clearly not representing the whole national conditions even if their population – being 83 the provincial capitals among the 100 most populated Italian towns – represent the 28.8% of the total population of Italy.

Table 1. Cities' size.

Inhabitants (in 1.000) (2011)	Freq.	%
<50	28	25.2
50-100	40	36.0
100-200	28	25.2
200-400	9	8.1
>400; max: 2,614	6	5.4

The data at our disposal confirms the well-known, perceived, or maybe sometimes taken-for-granted, difference between Northern and Southern-Insular Italy. This difference operates on many levels, being climatic feature, age composition, family size and per-capita income – i.e. some of the variables we used to explain the variability of the levels of consumption – only some of the possible examples. Higher densities in northern (mainly North-Western) towns are partially due to the fact that in many cases they have, for both historical and geographical reasons, smaller territorial extensions than towns of the other zones, so that agricultural lands, wooded lands and naturalistic sites are beyond town's administrative borders. At the same time we can say they are still deriving from the massive phenomenon of internal immigration that accompanied the industrial development of Northern (again, mostly North-Western) towns in the 1960s and 1970s.

Table 2. Primary explanatory variables.

Variable	Zone	Mean	Median	St.Dev.	Min	Max
Degree-days	NW-NE	2394	2418	385,8	1201	3043
	C	1803	1715	300,5	1220	2324
	S-I	1336	1226	490,7	707	2514
	All	**1863**	**1885**	**633,5**	**707**	**3043**
Pop. Density (2011)	NW-NE	1411,6	1003,7	1328,5	234,5	6786,1
	C	799,3	464,1	810,5	154,9	3484,7
	S-I	950,8	362,4	1456,8	65,3	8202,3
	All	**1113,1**	**732,0**	**1318,2**	**65,3**	**8202,3**
Family size (2010)	NW-NE	2,11	2,13	0,11	1,80	2,31
	C	2,26	2,25	0,12	2,00	2,49
	S-I	2,48	2,51	0,18	2,15	3,04
	All	**2,28**	**2,24**	**0,22**	**1,80**	**3,04**
Income (2010)	NW-NE	16298	16133	1705,9	13218	22604
	C	14404	13836	1979,6	11650	19699
	S-I	11061	10634	1704,6	7033	15506
	All	**13864**	**13898**	**2952,0**	**7033**	**22604**
Ageing Index (2009)	NW-NE	197,5	193,4	29,3	126,6	257,0
	C	183,9	179,7	31,3	106,8	250,6
	S-I	144,4	143,1	29,5	87,3	234,1
	All	**173,9**	**177,2**	**38,3**	**87,3**	**257,0**

Both of the two geographically most distant zones are characterized by areas with climatic conditions that are quite different from the average climatic conditions of their respective zones. The coastal region of Liguria, in Northern Italy and the mountainous areas of the Apennines in Southern Italy have, respectively, significantly higher and lower temperatures than their co-zonal provinces. Degree-days is an important explaining factor of energy use for heating. Data on energy consumption could have been eventually influenced by climatic anomalies. Annual average temperatures were high in both years 2002 and 2011 if compared with the historical temperatures of the period 1961-1990. More precisely, years 2002 and 2011 annual average temperatures were respectively almost 1°C and 1.3°C higher than the annual average temperatures of the period 1961-1990. However, the annual average temperatures of these two years are situated very close to the tendency line of the period 1961-2012. That is another reason explaining our choice to continue keeping these two years as points of reference.

3.3_Changes over the period 2002-2011

The percentage variation of the dependent variables has been higher where the initial levels were lower. While that could be found being not so much surprising, at the same time we should not forget it was not an inevitable outcome. Moreover, what is relevant is the fact that - as it results from simple correlations among 2002 levels of consumption and their percentage variations in the period 2002-2011 (Table 3) – their force may significantly vary from one case to another, while in other cases there is no statistically significant correlation.

Table 3. Variations between 2002-2011 (R Pearson).

Variable	R	Variable	R
Electricity	**-.511**	Income	**-.838**
Water	**-.458**	Ageing Index	**-.829**
kWh	**-.440**	Family size	**-.558**
Natural gas	**-.424**	Pop. Density	*-.206*
Motorization rate	**-.420**	Legend:	
Wastes	-.172	Bold: p<.01	
LPT Demand	-.042	Italic: p<.05	

Simple correlations among structural variables show the highest coefficients (with the only partial exception of population density (p<.05)). For many of the consumption variables, the coefficients are quite similar among them, with the notable exceptions of those related to wastes and LPT (Local Public Transport), whose coefficients are not statistically significant. Another important finding emerges by looking at the variations of the Coefficients of Variation (CV). The differences among provincial capitals are decreasing on the great majority of the aspects we controlled for. That is definitively clear for what refers to the socio-demographic variables we used (Table 4), were the CV decreased even within each of the three geographic zones.

A more differentiated situation characterizes the variations of consumption variables. For all of the environmental indicators used here the mean values of per-capita consumption show an increase, with the exception of the consumption of water, as it can be seen in Table 5. At least that is valid through a national level perspective, because by dividing the sample into geographic zones different paths emerge, and where the most significant lie in the fact that Northern provincial capitals show steady levels of consumption.

Table 4. Variation of primary explanatory variables.

Variable	Zone	Mean t0	Mean t1	Mean var.	Coeff. Var. t0	Coeff. Var. t1
Pop. Density	NW-NE	1390,0	1411,6	1,55%	0,958	0,941
	C	781,5	799,3	2,28%	1,025	1,014
	S-I	968,0	950,8	-1,78%	1,550	1,532
	All	**1107,6**	**1113,1**	**0,49%**	**1,206**	**1,184**
Family size	NW-NE	2,18	2,11	-3,38%	0,060	0,054
	C	2,39	2,26	-5,47%	0,063	0,055
	S-I	2,69	2,48	-7,73%	0,068	0,071
	All	**2,40**	**2,28**	**-5,00%**	**0,113**	**0,096**
Income	NW-NE	14614	16298	11,52%	0,108	0,105
	C	12595	14404	14,36%	0,151	0,137
	S-I	9170	11061	20,62%	0,177	0,154
	All	**12074**	**13864**	**14,83%**	**0,246**	**0,213**
Ageing Index	NW-NE	202,9	197,5	-2,65%	0,179	0,148
	C	182,9	183,9	0,51%	0,232	0,170
	S-I	118,1	144,4	22,34%	0,226	0,204
	All	**169,2**	**173,9**	**2,79%**	**0,305**	**0,220**

Table 5. Variation of consumption variables.

Variable	Zone	Mean t0	Mean t1	Mean var.	Coeff. Var. t0	Coeff. Var. t1
kWh	NW-NE	7588,6	7600,0	0,15%	0,264	0,231
	C	5339,2	5819,3	8,99%	0,226	0,233
	S-I	3348,2	3476,6	3,84%	0,348	0,317
	All	**5771,4**	**5914,1**	**2,47%**	**0,426**	**0,394**
Water	NW-NE	207,9	180,0	-13,41%	0,155	0,160
	C	181,0	155,2	-14,26%	0,182	0,184
	S-I	165,3	162,2	-1,85%	0,205	0,195
	All	**185,9**	**168,3**	**-9,49%**	**0,205**	**0,187**
Wastes	NW-NE	607,2	603,8	-0,56%	0,164	0,169
	C	636,3	648,1	1,85%	0,173	0,155
	S-I	517,8	539,3	4,15%	0,179	0,263
	All	**577,3**	**586,6**	**1,61%**	**0,190**	**0,213**
LPT Demand	NW-NE	113,6	126,7	11,56%	1,157	1,192
	C	93,6	95,7	2,25%	1,185	1,344
	S-I	49,4	46,3	-6,30%	1,009	1,074
	All	**85,3**	**90,1**	**5,65%**	**1,248**	**1,356**
Motorization rate	NW-NE	626,8	621,2	-0,90%	0,077	0,081
	C	661,9	668,8	1,04%	0,076	0,084
	S-I	600,0	650,3	8,38%	0,101	0,088
	All	**622,8**	**642,1**	**3,11%**	**0,093**	**0,089**
Electricity	NW-NE	1181,2	1187,8	0,56%	0,086	0,085
	C	1128,9	1177,6	4,31%	0,103	0,105
	S-I	1084,0	1178,9	8,75%	0,175	0,152
	All	**1132,8**	**1182,4**	**4,38%**	**0,133**	**0,117**
Natural gas	NW-NE	610,2	610,7	0,08%	0,308	0,272
	C	401,0	442,1	10,25%	0,281	0,290
	S-I	221,9	224,3	1,11%	0,531	0,499
	All	**443,1**	**452,3**	**2,09%**	**0,517**	**0,487**

[2] The before mentioned correlation coefficients (Pearson's) too are based on the sample without outliers.

Two limitations of our data set should be accounted for before going on. First, the quantity of wastes is expressed in kg per-capita, so that it does not tell too much about its composition – and consequently about its environmental impact – so that it might have varied not only because of changes in household consumption practices, but also of differences among local recycling systems. Second, the motorization rate tells us about cars ownership and not about cars utilization, even if it could be considered as a proxy of it. Has LPT demand behaved as a substitute for private transport? We have not a clear answer to this question. Indeed, LPT demand variation has no correlation with the variations of other variables, but with the variation of the motorization rate ($R = -0.199$; $p < .05$). However, it is not a very strong correlation. Moreover, the correlations calculated within the three geographic zones cannot support its robustness. Indeed, they are even weaker. The different increases in electricity and natural gas consumption in Central and Southern-Insular Italy can be explained by the fact that the use of natural gas for heating does not take place in the warmest provinces where, if necessary, other heating methods are mostly used, by means of electric energy being one of them.

3.4_Data preprocessing and regression model

After having showed the features of the most important variables in our model and some of their correlations, we used some regression models in order to capture the factors explaining the variability of the levels of consumption (for both years 2002 and 2011) as well as the variability of their percentage variations between years 2002 and 2011. Different sets of explanatory variables were chosen according to the variable whose variability was to be explained. Socio-demographic factors show strong correlation with each other, making multicollinearity an issue for the power of the regression models. Our preferred method for model selection is then forward stepwise selection because it allows to rank the explanatory variables based on their importance, and in sequentially adding variables to the model, it minimizes multicollinearity (Kavousian et al., 2013). Outliers were excluded based on the following method[2]: for all variables having curtosis and/or asymmetry statistics $\geq|1|$ their Z-scores were calculated and values with Z-scores $\geq|3|$ (if any) were excluded. This procedure (that was only applied for the entire data-set and not at the level of the geographically based sub-samples) was repeated till having all Z-scores between -3 and +3, and till obtaining values of curtosis and/or asymmetry being all between -1 and +1, for a maximum of three times. We then used a pairwise method for the selection of cases, as listwise method prevented almost 25% of the cases from being computed into the regression models. While Degree-days was used only for electricity, natural gas and kWh, all the other variables (as well as their variations) we before referred to as Primary explanatory variables were inserted into all regression models. The variables we before referred to as Secondary explanatory variables were only used for specific regression models. Dependent variables at 2002 were inserted only into the regression models for their respective variations. We then ran the regression models not only with the entire sample, but also with the three sub-samples, each one of them composed by the provincial capitals of the three main geographic zones. The results of the regressions for the

Central provincial capitals are not discussed here mainly because the results we obtained (or that we could not obtain) are weakened by the limited number of provincial capitals by which Central Italy is composed.

4_Summary of findings

At the national level the explanatory power of our models (adjusted R-square value) ranges from 0.143 (Wastes 2011) to 0.737 (LPT Demand 2002 - with LPT Offer in the model). For all cases but one, where it was almost constant (LPT Offer), our models lost their ability to explain variability in the passages from year 2002 to year 2011.

Income. Where income was an important explanatory variable it however lost, partially or completely, its power to predict variability, only gaining momentum for what refers to LPT.

Population Density. It increased its power to predict variability for what refers to water and motorization rate, while losing it for what refers to LPT.

Degree-days. It only explains a little share of the variability of the consumption of electricity, natural gas and kWh. Nonetheless, it slightly increased from 2002 to 2011.

Ageing Index. It completely lost its power to predict the variability of motorization rate and electricity consumption. It weakly became an explanatory factor of natural gas and kWh consumption.

Family size. It is the only factor that help us explaining the variability of waste generation. It completely lost its power to predict the variability of electricity consumption and LPT Demand; however, it was the most important factor explaining the variability of the former in 2002.

Tourist Attraction Index. Contrary to our early expectations - that were based on the fact that as consumption levels are expressed as per-capita consumption (of resident people) higher rates of presence of commuters, city users and so on, could sensibly modify the values - almost all the secondary explanatory variables played no role in explaining variability. The only exception is the Tourist Attraction Index. It explains only a little share (and only in 2002) of the variability of the consumption of water, electricity and kWh. However, in this latter case the Beta coefficient is negative. The higher coefficient and the higher share of explanatory power that is registered in Northern capitals suggested us how to interpret this somehow counter-intuitive outcome. Higher levels of Tourist Attraction Index characterize both warmer (seaside) and cooler (mountain) provincial capitals. While for the former there is a minor use of energy for heating, for the latter the heating services are likely to be obtained with energy sources (like wood, for example) that are not taken into consideration within the Urban Environmental Indicators.

Given the relevant structural and socio-demographic differences between Northern and Southern-Insular provincial capitals, a bigger insight could derive from the applications of the regression models to these distinct sub-samples. We can see that variability is better explained in Southern-Insular Italy for what refers to the consumption of energy, while in Northern Italy it is better explained for what refers to the variables related to mobility.

Mobility (motorization rate and Local Public Transport). Not only population density is the most important explaining factor for Northern capitals motorization rates, but it also became even more important. Population density also gained a role in it in Southern-Insular capitals, with income continuing being there (with a decreased importance in 2011) the main explanatory factor. Moreover, population density is by far the most important explanatory factor for LPT (both demand and offer) in both Northern and Southern-Insular provincial capitals, with a secondary role of socio-demographic aspects like family size and Ageing Index.

Energy consumption (electricity and natural gas). Even if our model explains only a little part of the variability of energy consumption in Northern capitals, it is possible to say that it is explained by income levels. For what refers to Southern-Insular capitals, variability is (and is ever more) explained for the most part by Degree-days. It is relevant to notice that Beta coefficients are inverted between electricity and natural gas use, confirming the before mentioned hypothesis that in the warmest towns electricity is preferred to natural gas for heating.

Water and wastes. Our model is weak in explaining their variability, even within sub-samples. However, the application of our regression model to the production of wastes for the Southern-Insular sample seems to confirm the importance of family size as explanatory variable.

Variations. The last step we did was the application of our regression model to the variations (2002-2011) of the levels of consumption. At the national level the explanatory power of our models ranges from the very low levels of 0.030 and 0.031 (Variation of LPT Offer and Variation of LPT Demand) to 0.695 (Variation of motorization rate), while we did not obtain any explanation for the variation of the per-capita production of wastes. The levels of consumption at 2002 explain part of the variability of the variations, with the exclusion of LPT (both demand and offer) and wastes. That is evident for the energy consumption in Southern-Insular capitals where, according to our model and differing from what emerges from Northern capitals, the 2002 levels of consumption are the only explanatory factors.

A special attention should be paid to both private and public mobility. While in Southern-Insular capitals the main explanatory factor of the variation of the motorization rate is the variation of the per-capita income, for what refers to Northern capitals the demand for (and the offer of) LPT and the motorization rate are interrelatedly explainable. The above-mentioned findings are confirmed. Moreover, it emerges the situation in which LPT is operating as a substitute for cars ownership whose increase is hampered by the population density. Socio-demographic features are also playing a role in all that, with Ageing Index explaining the variability of both private and public mobility. This also happens with family size coefficients, suggesting that the differences in mobility schemes could be also determined by the prevalence of different family structures. Finally, it is relevant to notice that the variation of the per-capita electricity consumption in Northern capitals is explained by Ageing Index and family size. However, coefficients are inverted with respect to the regression model for the 2002 levels of consumption.

5_Conclusions

In this paper we attempted to approach the investigation on Urban Metabolism from an unusual distance, that is by comparing the metabolic profiles, and their evolutions over a decade, of a significantly high number of towns. Notwithstanding the limitations of the statistic model we used, also deriving from the fact that the variables we used were not designed to our aims, we dare propose here some hypothesis and some reflections, as some quite clear phenomena have been anyway emerging. While cities are given more and more relevance as sites were policies and innovations aimed at tackling climate change and curbing CO_2 emissions could be implemented, at the same time they are not isolated entities, being their metabolic features partly mutually interrelated, at least at a national level, so that a national-level guiding intervention could be somehow needed or appropriate. Indeed, cities have been changing their metabolic profiles in an homologous way, as it results from the generalized convergence towards common (and slightly increasing at the same time) levels of consumption, towards some standards of consumption that are more and more enrolling the Italian households in provincial capitals. At the same time, the socio-demographic variables have been converging at an even faster pace. This fact could explain, at least partially, the loss of predictive power that hit our regression model in the great majority of cases. This also happened within the main geographic zones, in the passages from the first to the last year of the decade taken into consideration. Further insights could derive from the expected data updates about the different categories of not residents using the cities, from updated and more disaggregated data about the productive and economic structure, from improved indicators about population density also taking into account the different uses of the towns' surfaces, from data about more and other items of consumption. The urban metabolism of the Italian cities is, at the aggregate level, stable in time. It means that, as it has been revealed by many studies, western urban systems have reached saturated consumption patterns. Expecting or forecasting future strong increasing levels of consumption will be difficult.

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POLITO INNOVATION DESIGN LAB: THE CASE STUDY OF INNOVATION DESIGN FOR FOOD

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Abstract

The Polito Innovation Design Lab is a University laboratory created to research and promotes initiatives that help to reach innovative project and broaden the culture of sustainable innovation. The mission of the lab is to manage, coordinate and carry out research projects about products, services or models able to meet real needs of people with a regards to territorial potential perspectives of technology, environment, economics, culture and social sciences. In this paper is presented the Innovation Design For Food (IDF) case study. The innovation challenges faced in this project aimed to redefine, reshape and produce social, economic and environment impacts and effects with a sustainable perspective in the different district of the city using the food as an enabling factor. The final scope of the project was to train and experiment the ability of sustainable design process to enhance a special context or territory, starting from the resources currently present in it. The paper presented is divided in two sections, the first go through an introduction and an explanation of the methodology and the design process adopted to achieve the results presented in the second section of the paper.

1_Introduction

The design role inside the company and the society is radically changing in recent years. If the design has become an essential asset in any product or service delivered in the market, other indicators suggest an increasingly importance of the role of design as a strategic tool in the vast landscape of innovation, as suggest Tim Brown (Cicoria. 2013). In fact if the innovation is a multifunctional force that must continually refine his form method and his meaning to be able to reply to new outcome issues (Tamborrini. 2014), the multidisciplinary nature of design fits in a natural way into the needs, managing in a proper manner these aspects. In addition, we are witnessing in every social and market field context, a speed and unpredictability that have dealt a blow to the old systems and established "modus operandi". The result is a growing complexity and a lack of predictability that affect industries, corporate and institutions that every day are looking to the right way to navigate into this fog (Josiassen & Rosted. 2014).
This scenario became even worst if we pair these kind of issues with the growing demand of sustainability in the society, economic and environment factors. All these aspects are the precondition why nowadays there are more attention into the research for tools able to handle the increasingly complex and apparent chaotic contexts of today. On this line and with the trend that opening up to the "golden age of design" (Walker, 2014), the research team of the Department of Architecture and Design is moving to study, to map, to re-define and to experiment a methodology capable to answer at new meanings and emerging needs for those who create innovation in order to progress and prosper (enterprise) and for those who need it to improve their quality of life (the user/subject) with a sustainable perspective. In order to give a structured response it was created the Innovation Design Lab. In the laboratory researcher and student are challenge in innovative sustainable initiatives

with the goal to research and learn how to manage, coordinate and carry out design projects able to meet real needs of people with regards to territorial potential perspectives of technology, environment, economics, culture and social sciences.

2_Sustainable Innovation Design

Sustainable innovation is nowadays not more a feature on the innovation eco-system but is an essential component of the innovation itself (De Biase. 2015) enabling green and growth to go hand by hand, and design (Walker. 2014) has gained the multidisciplinary expertise to drive it in the right way. Design with a sustainable perspective means to create new opportunities as new economic model, new social engagement and lifestyle improvements with a reduced input into the original context of introduction.
Sustainable endeavors are changing the vision of how and why we are designed. The context, the focus on reduction and reuse, or the smart allocation of resources, the delivery of better and more suitable product/service to users, the creation of new partnerships with the actors involved in the system, they are all pieces of the innovation system that has to be taken into account to make additional revenues or create new lines of business, solving at the same time social issues such as unemployment, social exclusion, health enhancement, education and so on. But when it comes the necessity to design a innovative project, with a sustainable approach, theory and practices are different aspects that have to work together. The theory is setting the perspective and the guidelines of the innovation project while the practice has to set up the tool able to answer to the challenges identified.
To manage this process we need clear and stable methodology. For that reason the Innovation Design Lab continuously research and study the various innovation theories and design methods come out in this area. But not only the first set of the research was to define very clear the scope of this methodology so the research team, following the studies of Larry Keely (2013) and Roberto Verganti (2009), set its own definition on sustainable innovation. Design as that the practice of creating a new viable value/benefits sustainable proposition (Gaiardo & Tamborrini 2015). In this definition, the aim of the innovation is focusing on delivering new, viable and concrete sustainable result activities with a tangible value/benefit for all the actors involved. Equally the design methodology adopted to guide the stage of product/service design innovation derives from the Systemic Design approach used and taught in design courses at the Architecture and Design Department (Bistagnino. 2009) and the well-know design Industrial process.

3_Design Methodology Process

The Systemic Design approach is not amenable to simple recipes or toolkits because of his complexity and his multi-faceted process, but it is the right approach to drive with awareness the achievement of the best possible result. The aim of this approach is to unlock and exploit the innate value of the context as a starting point. For that reason all the project have to start with a deep and careful analysis of the complex relationship between different

actors (individuals, society, enterprise, culture, territory, etc.) and the related cultural, economic and community area or territory.
Data and context are the two core of this approach. Nowadays more than ever the new information and communication technologies and in particular the ability to gather, analyze and disseminate large swaths of data and connect large number of people over broad areas have enabled a greater understanding of what surround us. This approach is a strategic way to face the design innovation activity to better meet the real need of a context.

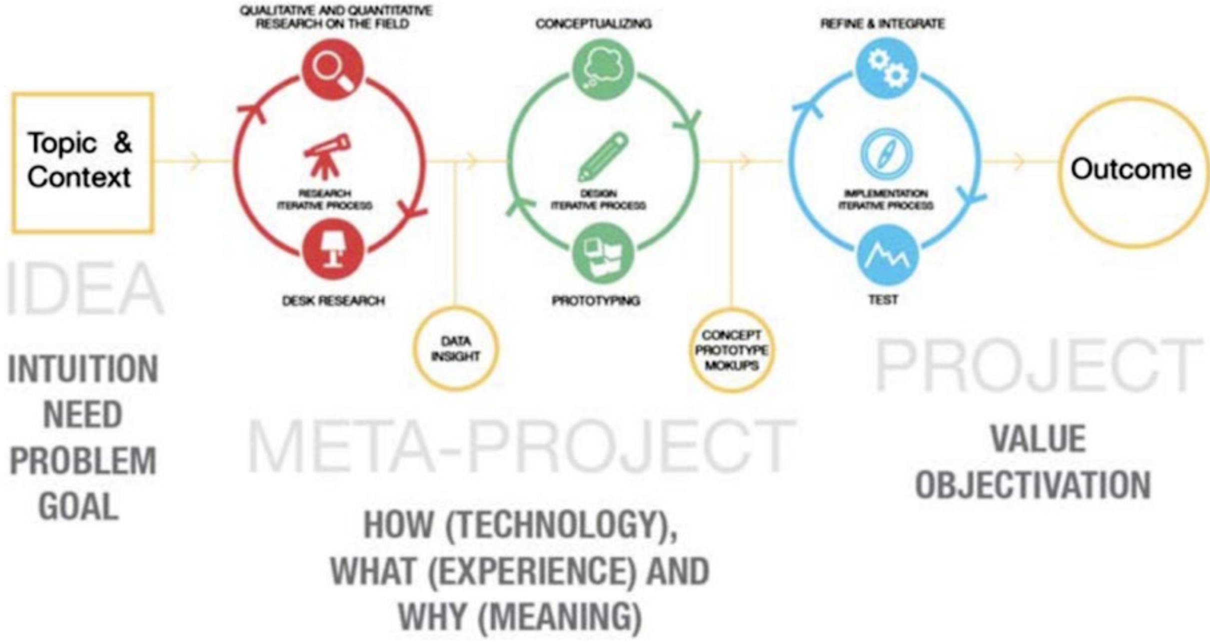

Figure 1. Design Process Schema.

The design process come out, described in general view in the picture (fig. 1), goes through in all the stage of the innovation design process. The preliminary step is the definition of the goal's project with the description of the topic and context action boundaries. The set up of these boundaries derives from what we would like to achieve and is drive by an intuition, an idea or an issue to solve. The meta-design phase, or rather the design expectations that will provide indications without the specific solutions to implement the project (Germak & Celaschi. 2008), starts and ends with two iterative processes: the research and the design step. In this phase, the assignment of the designer is to answer why he is adopting a solution, what is the solution and how the solution adopted will work.
The research step begins with the exploration and collection of broad and tangential information in order to examine the vast array of issues, features and relationship surrounding the topic. The analysis of this overall picture drives into a deep understand of the topic, outlining the real role of all the actors involved within their scope, their development and their relations in their operational context. The amounts of data generate the design analysis/data documentation. This output is the fundamental under layer leading into the second stage where it starts the iterative process of design. At this step, the designer have to develop guidelines and propose solutions in according to the research step, described before. The result of this stage as to be a functional prototype or mockup of the concept outcomes. The intent of this outcome is

to communicate and explain how the concept works and how it answers to the goal's project.
The last phase is the implementation of the concept with his development and the launch test phase where, with iterative tests, it is still possible to correct the problem occurred before to deliver the project over.

4_Innovation Design for Food

Innovation Design for Food (IDF) was born from an academic experience within the innovation master course of the Politecnico di Torino. The aim of it was focused on studying different districts of Turin and, starting from their problem and resources, introducing a sustainable innovation able to improve the social or the economic or both aspects with the use of food (supply chain and related things) as an enabling factor. In fact, the heart of the project was to transform the existing resources in the food sector, then it was necessary to know in deep all the infrastructure, the economic relationship, the human value and the cultural assets involved in this system before studying and conceiving any sort of improvement. The students were challenged in the creation of social and environmental innovations within specific areas of the city of Turin. In particular, the activity involved food as a symbolic element of identity, communication and information, in order to put in relation different cultures and enable initiatives on the socio-economic development. The experience was divided in two different phases: the research phase and the design one.
The research phase was structured to provide a large amount of material and details: first of all, the project team performed a complete mapping of the food business in the area (related to sale, consumption and distribution), which allowed us to understand the economic and commercial site. In this collection of data it was added a careful analysis on the livability, the everyday life and the perception of the area: these aspects, crossed with sociology, made an important contribution for the knowledge of the neighborhood's social reality. During this phase it was fundamental the continuous research and conversation with merchants and activities related to food. Therefore projects were created thanks to a wide-ranging vision that involved the actual capacities and the possibilities of future development. The selected projects meet all the requirements of environmental, social and economic; they aim to improve the quality of life using a mix of communication, productive and interactive skills.

4.1_Research phase

In order to find out the values of the territories, the different teams analyzed different types of qualitative and quantitative information as a quality of natural and built environment, together with identity elements and cultural living conditions, and the economic settlements of the neighborhoods around the city centre. In particular, this type of research was conducted with a research carried out to investigate the overall context of action in three main fields: environment, socioeconomics and the specific food field. Regarding the first and the second aspects, the project used traditional ethnographic methods to analyze the environment field (natural heritage, infrastructure, public spaces, mobility system, garbage system and quality perceived by residents) and the socioeconomic field (history, economic identity, quality of life, target of residents, culture, events, associations and economic fabric). The tools used in this phase ranged from interviews, empathy explorations, qualitative and quantitative data analysis, contextual maps, case history and value network maps.

The food field analysis was conducted instead with the collaboration of LARTU (Laboratory of Analysis and Territorial and Urban Representations) through an experiment for testing a digital mapping process. The data acquisition was entirely performed on the ground, using a laptop and a smartphone app that allowed users to use, create and share data maps, thanks to the link to a collaborative cloud-based platform.

The data collected were divided into four main categories: production (urban garden, social garden,...), distribution (street food, retail store, lorry owner, ...), sale (store, market, supermarket, ...) and consumption (coffee shop, restaurant, take-away, ...). For each category was made a distinction based on the nature of the food in terms of regional, national, ethnic, biological, vegan food, and so on. All the data were put into a map to analyze the distinction and the distribution of the different actors involved inside the food system in the city and in each district. The experiment produced useful data on the chain of production, distribution, sale and consumption of food. It encouraged students to reflect on the objectives of the design proposal, with extensive reflections on methods and times of living in the same city. In this way, it was possible to reconnect food to some aspects, among which:

- food as a source of well-being and health for different populations target, both inhabitants (elderly people, youth, children, foreigners-natives) and city users (employees, visitors);
- food as a testimony of culture and traditions rooted in the territory;
- food as a source of innovation in the agroindustrial chain;
- food as a vehicle for interaction and exchange among different ethnic groups and cultures;
- food as a urban polarity and "attractor", even against new emerging polarities (universities);
- food as a symbolic element of socio-cultural identity.

4.2_Design phase

After the research phase, students knew the characteristics of their district of interest. Therefore, it was possibile to pass at the second step: the design phase. In this phase each team proposed design concepts able to introduce a social improvement in their neighborhoods. This was possibile passing from the resulting data, of the previous step, into the formalization of guidelines for enhance one territorial aspect, mitigating or solving a problem, or implementing a project that could bring a benefit. In this case, the systemic approach led the students to formulate design concepts with a general perspective on cause and effect with elements that can support their choices.

Figure 2. Cibogramma.

4.3_Project

The study of the field of intervention has driven the iterative phase of idea generation that has resulted in different concepts and prototypes. Here we present the most significant outcomes that exploit the full potential of innovation in food at local level.

4.3.1_Cibogramma

The aim of Cibogramma is to relate the different ethnic groups that reside and live the neighborhood Aurora Rossini. The multicultural aspect characterizes the area, but often it represents a barrier; using food as an instrument for the expression of customs and traditions of a community, the project want to show the potential of the multiethnic aspect, for stimulating relations and knowledge.

Students gave special attention to the research of a communication form that allows each one to interact; this has brought to design postcards, placemats, recipe books, app and website, that illustrate the different recipes using an iconographic language. The Italian language is used to explain ingredients, offering to foreign people the possibility to learn some new words. By the design of some events (workshops, theme meals, games and labs) integration and relation are facilitated. In fact, the events allowed the comparison among people and they fostered the diffusion of the different cultures.

Cibogramma (fig. 2) was designed by Fabio Conte, Stefano Lattanzio, Chiara Lorenza Remondino, Barbara Stabellini.

4.3.2_Cibamenti

Cibamenti is a new way to experience the local market, in order to introduce young people to a targeted and nutritionally correct purchase: it means to educate to quality and sustainable food, through the buying of pre-impostate bags of food on the online platform, and their distribution through a new stand at the market.

The project aims to convey the users towards sustainable eating habits, made of healthy and local food, because it is selected and quantified, based on criteria supported by certifications and by the opinion of experts. In particular, the project is designed for the target of students, so it responds to their needs, re-evaluating territorial relations between the university campus and the near market placed in Vanchiglia; the intention is to inform and

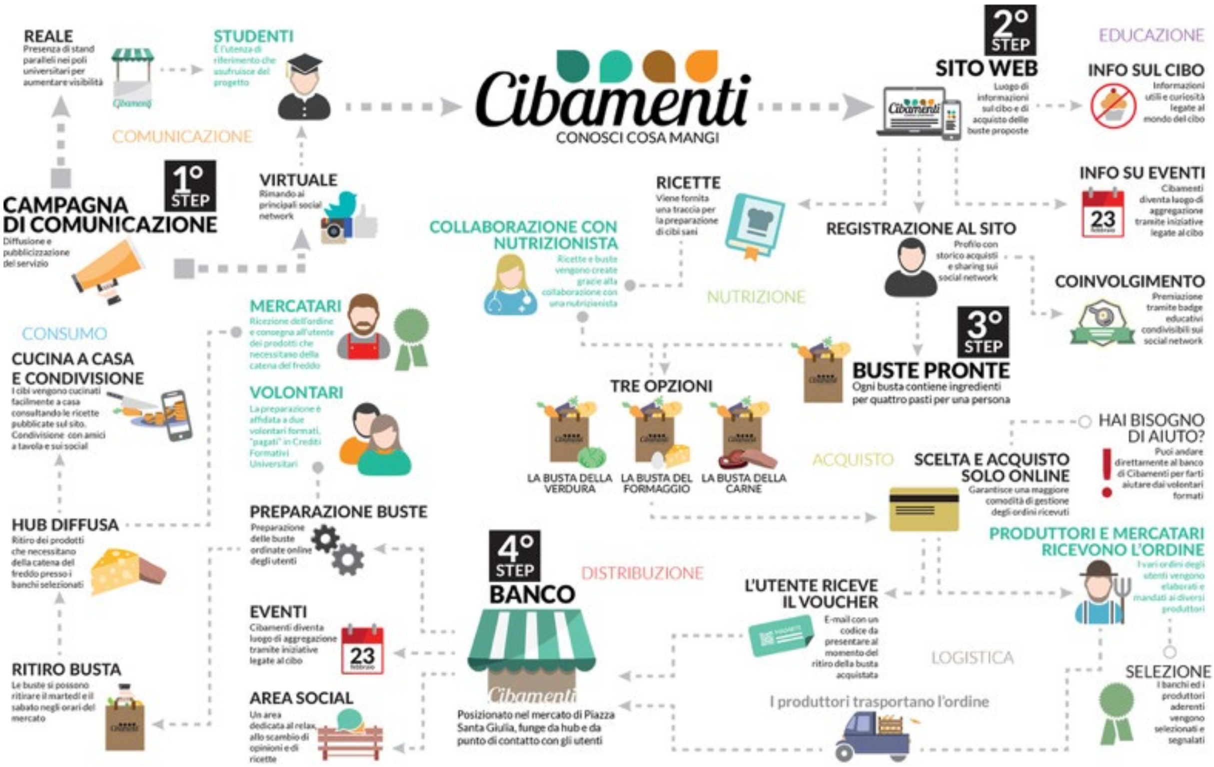

Figure 3. Cibamenti.

educate users, to simplify the recognition and the purchase of products, to provide simple and healthy recipes to cook them.
Cibamenti (fig.3) was designer by Elisa Cravotto, Sara Gomez Gomez, Eric Lindqvist, Luca Magnani, Mauro Sorrentino, Maurizio Vrenna.

4.3.3_BiCibo

BiCibo aims to promote the quality of food, discovering the retail district of San Salvario in Turin. The main purposes of the project are to inform and educate the consumption of healthy food and to facilitate the re-evaluation of the activities involved.
The products of these stores can be tasted by people through a "street food truck" that stop in strategic points of the district, reported with a specific communication. This activity takes place 2 or 3 times a week, proposing snacks from the stores involved; each event has a different theme. Users can

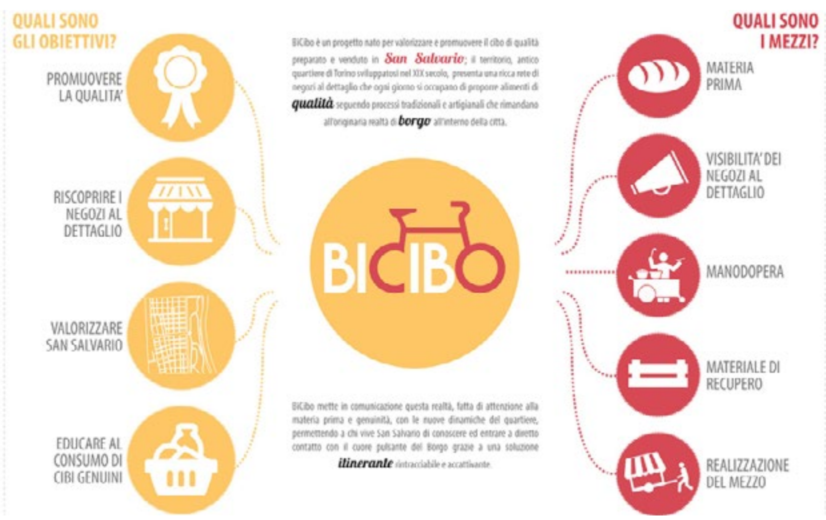

Figure 4. BiCibo.

learn about the products and can be informed about the activities of the retail stores through a map, a brochure with promotions and product information, and a mobile app. To make identifiable traders involved in the initiative, markings and billboards are exposed on the stores.
BiCibo was designer by Lorenzo Gabini, Laura Jaramillo, Simona Patania, Giada Pezzi, Carola Stinchelli, Tania Tempo.

4.3.4_Qualità Percepita

Explaining what you feel when dealing with food is never easy and that is why the Qualità Percepita was born. Its purpose is to enable clients to describe in the best possible way the experience had in every food related place located in the Crocetta neighborhood.
The key idea is to straighten the identity of Crocetta as the "good neighborhood" of Turin, making perceptible his hidden resource: food. Each of us, indeed, perceives quality according to its own logic; Qualità Percepita has the purpose of making more objective the criteria that normally drive to the same perceptions. The project takes the form of a website in which one can search and evaluate food related places through 12 criteria based on perceptual principles. Qualità Percepita is a project designed for those who make their concerns about well-being and their awareness about each purchase, the base of the food culture that binds the interest in good food to the refinement of products with special characteristics.

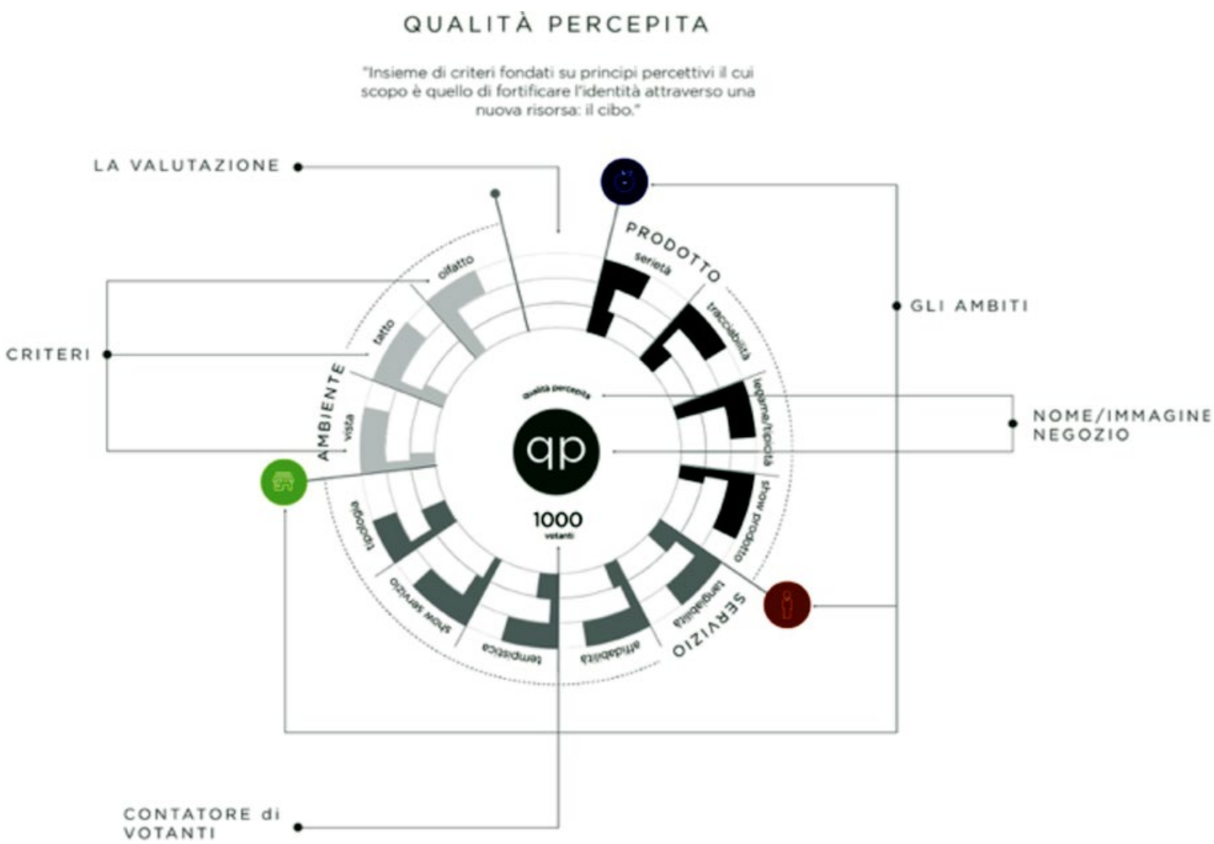

Figure 5. Qualità Percepita.

Qualità Percepita (fig.5) was designer by Alejandra Aguilar, Agnese Mantovani, Debora Pilati, Nikolaj Strömberg Gröndahl, Francesca Tedeschi, Serena Zerbinati.

5_Conclusions

Contribute, inspire and advocate to the on-going evolution on innovation process design and innovation-related tool-making in a ceaselessly changing world with a sustainable horizon is one of the core scope of the Innovation Design Lab.

For that reason the aspiration of our research and laboratory is to experiment and continuously redefine the best methodology and approach to support the transformation of sustainable initiatives and ideas in a tangible outcome able to improve and progress the human quality conditions.

Through the application of these practices on innovation purposes, and with the creation of new visions capable of going beyond the mere commercial and technological aspect, we strong believe, as the first our results confirm it, the sustainable design process can affect territorial value systems by creating new businesses and by leading the society towards a new equation: Innovation=Sustainability.

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TOWARDS A MICROFOUNDATION OF URBAN METABOLISM

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Abstract

By recalling the theoretical approach derived from the conceptual framework of Societal Metabolism the paper is focused on the relevance of renewing the concept of urban metabolism in order to better address urban environmental impact toward a more efficient metabolism of cities. Among other issues, prevention and reduction of urban solid waste have to be primarily taken into account since waste represents an enormous loss of resources in the form of both materials and energy and at the same time may produce a considerable environmental impact. Waste production is an important quantitative and qualitative indicator of how much efficient an urban system is, particularly in relation to the use of natural resources.
The study proposes an improvement of conceptual framework and methods so far developed for studying and operationalizing the urban metabolism framework. By adopting the model of urban regulation regimes the way stakeholders influence the urban metabolism is investigated to catch the emergence of patterns at urban macro level. The objective is to provide an holistic model where urban metabolism emerge at the macro-aggregate level of the city as a result of the behaviours, practices and interactions of agents and actants at the different levels of the urban system (households, enterprises, corporate actors, communities and local public authorities).

1_The state of the art in Urban Metabolism studies

1.1_Conceptual framework

In order to explore how much energy and how many materials are consumed by human systems, scientist use *metabolism* as a metaphor of all the socio-economic and natural processes by analogizing the city to an organism: the city grows by absorbing nutrients from outside its boundaries and discharge the waste to its environment. But more than only a metaphor, *metabolism* is a theoretical category useful to understand, explain and accounting the relation of human systems to its environment so that *societal metabolism* is an input/output mechanism aimed to maintain the turnover connected to the conversion of matter and energy in useful things, an intrinsic feature in the reproduction of any organism (Padovan, 2014). By adopting metabolic approach socioeconomic researchers allowed to introduce the tools developed during more than a century of research on ecological systems and their metabolic processes to improve the processes of socioeconomic systems.
Whatever the system to which it is referred (city, household, firm), metabolism corresponds to the whole process of reproduction of the system itself and of its parts. Among metabolic approaches we can find Industrial Metabolism, Urban Metabolism, MuSIASEM approach (Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism), Household Metabolism. Any of them have their specific quantitative methods of analysis of metabolic exchange between social and natural systems. Even if these different approaches are closely interwined, in the following we focus on Urban Metabolism, since urban systems are gaining more and more relevance in the organization of human activities. According to the UN-HABITAT's Cities and Climate Change

global report on Human settlements 2011, the world's cities are responsible for 75 per cent of global energy consumption and up to 70 per cent of GHG emissions, while occupying just 2 per cent of its land and being home to just half of the global population (Padovan et al , 2014). As the demands for higher inputs of materials and energy to sustain the growth of cities continue to increase, understanding the metabolism of cities becomes extremely important for policy makers and decision makers.Cities present both the problems and solutions to sustainability challenges of an increasingly urbanized world (Grimm et al., 2008).

Urban Metabolism (UM in the following) is a multi-disciplinary and integrated platform that examines material and energy flows in cities as complex systems as they are shaped by various social, economic and environmental forces. Similar to biological organisms and ecosystems, cities cycle and transform incoming raw materials, food, water and fuel into physical structures, biomass and waste. Factors such as urban structure, form, climate, quality and age of building stock, urban vegetation and transportation technology can influence the rate of a city's metabolism (Holmes 2012) where the efficiency of metabolic process are measured as the ratio between inputs and outputs.

During the 50 years since the concept of urban metabolism was proposed (by Wolman in 1965), this field of research has evolved slowly. On the basis of an analogy with an organism's metabolism, the concept of urban metabolism has become an effective method to evaluate the flows of energy and materials within an urban system, thereby providing insights into the system's sustainability and the severity of urban problems such as excessive social, community, and household metabolism at scales ranging from global to local. Other scholars believed that it was not suitable to treat cities as if they were organisms.16 Instead, they believed that cities represent hybrid systems that combine multiple organisms, including humans, animals, and plants, in ways that are more similar to an ecosystem than to an individual organism. It then becomes possible to simulate material cycling and energy flows using knowledge and tools from ecosystem research (Zhang et al 2014).

With respect to this 'positivistic' framework, even if it is useful and reasonable, it is worth to recall two remarks. First of all, cities are not only physical entities but also symbolic, social, cultural machines. As a result UM may consist of not just material and energy cycles but also of highly politicized physical and social processes. These scholars move away from a society-nature dualism to seeing the city as a process of metabolically transformed nature, a dynamic intersection between social and bio-physical dimensions to urban space, even a socio-natural hybrid or a cyborg of machine and organism (Padovan 2014). Second, there is a crucial difference between a living organism and the social system. In the case of individual living organisms, the exchange of matter and energy with their environment is oriented to the simple non-teleological reproduction of the organism itself. In this case, modalities of recovery and transformation of the necessary elements for the reproduction of the organism's life change very slowly in time and above all, when they reach a balance, they are maintained over time. The social or socio-economic metabolism instead is not oriented to an equilibrium condition, but to

continuous growth. For social sciences there aren't any limits to the physical growth of the objects to consume and reject in the environment, in a word in the growth of whole social system.
The latter remark recalls issues directly connected with sustainability of UM and in particular with consumption of resources and emission of wastes. Too fast and linear metabolic processes overcome social stability generating crisis, as for instance the rift between consumption and resources availability and flows that are predominantly linear or that form open loops (i.e., losses from the system) are not sustainable. Therefore, it is essential to encourage circular material flows and, as much as possible, transform wastes into resources. The former call for a renewing of the conceptual so as of the methodologies applied in studying UM processes. The two are linked in the sense that several research challenges, described in the next section must be resolved before it will be possible to encourage practical use of urban metabolism research to support decisions and policy development by urban planners and managers.

1.2_Methodologies

The methodology to undertake a UM study invokes the principles of conservation of mass and energy. Ideally this requires quantifying all mass and energy flows into and out of a city – including changes in storage – over a calendar year. In practice, however, the urban metabolism is quantified as urban inputs, outputs, and storage of energy, materials, nutrients, water, and wastes. At a first level of engagement, urban metabolism is usually studied or quantified by aggregate measures (though not precluding finer scale analysis) such as total annual electricity use or water consumption. This is analogous to human metabolism, which is measured by aggregate indicators like total energy or oxygen input per day. (Kennedy et al., 2014
This is the common methodological basis over which different methods and approaches have been developed by researchers, mainly in the last two decades (Zhang 2014).
The starting point is represented by the so called *black box models* in which the internal components of the system were not considered. Black box models reflect the overall inputs and outputs of a city and its activity intensity and scale to provide a macroscale indicator, analogous to human information such as weight, temperature, and blood pressure. Black box models can be used when little data is available and provide an overview of urban metabolic efficiency and the degree of sustainability.
In contrast, *subsystem models* try to open the black box to reveal its components. These models describe details of the flows among subsystems and the factors that influence these flows and are analogous to examining individual human organ systems (e.g., the heart and blood vessels); however, this requires much more detailed data.
Finally, *simulation models* have also improved as researchers accounted for circular metabolic flows for livability and for the network characteristics of systems. On the one hand, network models go beyond the traditional black box approach to analyze the internal characteristics of an urban metabolic system by transforming processes and nodes into mathematical descriptions

of the flows among pairs of components. On the other, in addition to static models that focused on the value of a parameter (such as metabolic efficiency) at a given point in time, researchers have developed dynamic models that account for changes over time.

Looking at these experiences from the perspective of the research object, from the foundation of UM approach, two categories of research methodologies have been so far adopted. One refers to the *element-based* method (e.g., material flow analysis, life cycle analysis …) focusing on the specific element flows and stocks of urban ecosystems with a range of aggregated indicators. The other, *structure-based method*, e.g., ecological network analysis, is also introduced to explore the urban metabolism via the layout and functioning of urban ecosystems underpinning their industrial and biophysical processes, which uncovers the black box of urban ecosystem and pursues 'strong sustainability' by tracking mutual relationships control pathways among various socio-economic sectors and surrounding environment.

Thus, UM research seems to have evolved to the point at which it can now provide important insights into the functioning of an urban system studies by being evolving from models of linear to cyclic processes and then to network models. But notwithstanding this process of growing methodological complexity, the most common framework adopted in UM studies still remain Input-Output / Stock and Flows models based on the measurement of a number of macroindicators[1] (see an example in table 1) within a black box model (scheme A in figure 1) that considered only overall inputs and outputs or in a more advanced detailed model that examined (maybe through a network approach) the inner workings of the urban system (settlement dynamics) in increasing detail (Scheme B in figure 1).

[1] A list of the most common indicators organized by four different dimensions of the I-O model is provided by Hoornweg (Hoornweg D.et al 2012): INFLOWS (Food, Water-imports, Water-precipitation, Groundwater abstraction, Construction Materals, Fossil Fuels, Electricity, Total Incoming Solar Radiation, Nutrients); PRODUCED (Food, Construction materials); STOCKS (Nutrients, Construction materials, Landfill waste, Construction demolition waste); OUTFLOWS (Exported Landfill waste, Incinared waste, Exported recyclables, wastewater, Nutrients, SO2, NOx, CO, Volatile organics, Particulates, Methane, Ozone, Black Carbon).

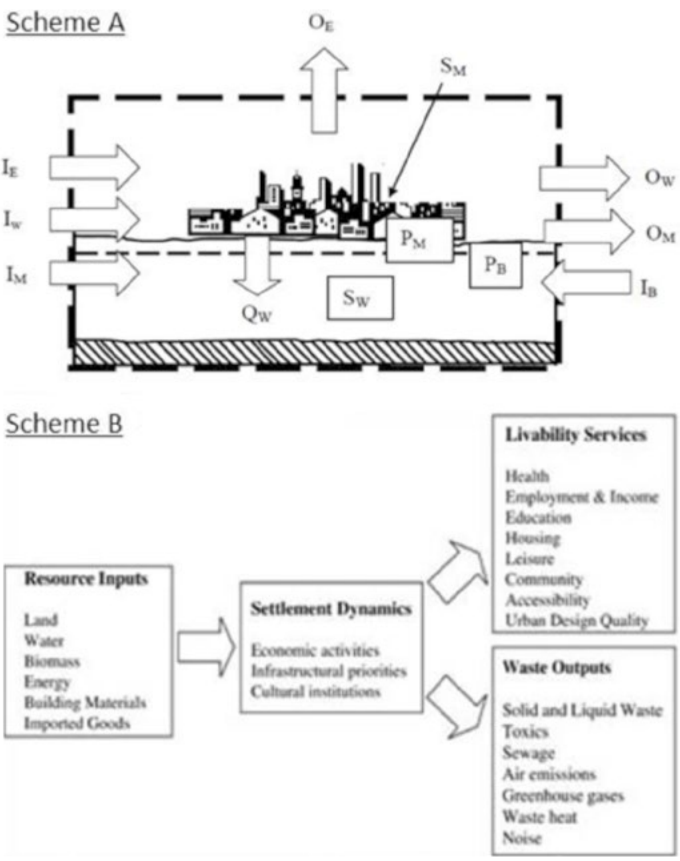

Figure 1. Two I-O schemes of Urban Metabolism: Scheme A (Kennedy 2014) showing inflows (I), outflows (O), internal flows (Q), storage (S) and production (P) of biomass (B), minerals (M), water (W),and energy (E) Scheme B (Newman, 1999) Extended metabolism model of human settlements

2_One step beyond

2.1_Strengths and limits of the current approach and methodologies

The Um framework as briefly described above shows a number of useful features in order to face the comprehension and management of the increasing growth of cities and related demands for higher inputs of materials and energy and namely: identification of the system's boundaries; accounting for inputs and outputs to the system; call for an analysis of policy and technology outcomes regarding sustainability goals; integration of social science and biophysical science/technology.

Behind these advantages stands first of all the effort to provide a rigorous tool for analysing relevant energy and materials pathways at different scales that can lead to the development of management systems that increase resource use efficiencies, recycling of wastes and conservation of energy. Notwithstanding the different approaches to the analysis of metabolic processes, it is possible to identify some relevant concepts and tools that have been recognized as a common heritage of the UM approach (Holmes et al):

- **Emergy** is the available energy used directly or indirectly to make a product or deliver a service (that is the 'embedded' energy) It measures the work of nature and humans in generating products and services and serves as a common metric of environmental and economic values thus connecting ecosystems and socio-economic systems.
- **Material Flow Analysis**. Based on the principle of mass conversion (where mass in = mass out + stock changes), MFA measures the materials flowing into a system, the stocks and flows within it and the resulting outputs from the system to other systems thus providing a system level understanding of how a city, region or nation functions.
- **Life Cycle Assessment**, aimed at evaluating the potential environmental impacts of a product system throughout its life cycle by providing a cradle-to-grave assessment of a process including direct, indirect, and supply chain effects.

More in general, results from the application of an UM framework can aid planners and managers to improve resource use in cities; to reduce environmental degradation; to identify environmental impacts of energy, material, and waste flows; and to isolate problem areas in need of attention. It is noteworthy that the establishment of these common tools may represent at the same time the strength and the limit of the UM approach as it has developed so far. In fact most research on the flows of materials and energy has concentrated on traditional accounting methods and on establishing a technical framework. What is missing is first of all a real standardization of the UM paradigm since in the practice the tools above described may be based on heterogeneous data. In fact, even at the aggregate level, there are several measures of energy and material flows in the urban metabolism in large part because data collection is a formidable challenge and not every urban systems is covered by information in the same way.

A second critical aspect is the need for a correctly implemented multilevel approach that is find a way to explore and combine the results of analyses at different scales. Researchers usually treat cities as homogeneous structures and use data compiled at a relatively coarse resolution (e.g., using top-down methods) and ignore the differences within the city, such as differences between central and suburban areas. In addition, few researchers have combined studies of material and energy flows with the locations of the flows or with the activities and humans that produce them.This has resulted in a lack of research based on high-resolution data (e.g., bottom-up methods). If UM has so far not been widely used to support urban planning and management is mainly because the aggregation of data at urban or regional levels cannot show the details within an urban system that are the target of planners and managers.

The third crucial aspect is the most relevant in constraining the explanatory power of UM approach and pertains to the dramatic underestimation of the social component of urban metabolic processes. Urban metabolism is made by bundles of everyday life activities aimed at the stable and recursive reproduction of social material life of human beings. They are the basic units of metabolism, the triggering activities that start metabolism while at the same time they are outcomes of metabolism itself. In analysing UM has to be kept in mind that its processes of UM can vary consistently depending on different social configuration of the urban systems themselves (relation between technical progress and nature appropriation and between accumulation dynamic and social reproduction) and the specific ways by which UM is desinchronized with its environment are determined by a heterogeneous constellation of social practices (Padovan 2015). Urban systems cannot be considered as an homogeneous whole and the consideration of relations among different subsystems it is not enough to effectively open the black box of the metabolic processes. The activities carried out by the agents at the micro-individual level have to be taken into account to reach a sound understanding of the mechanisms that determine the overall effect in terms of material and energy use by the urban system.

From the above remarks clearly emerges the need for a multidisciplinary approach that holistically accounts for all of the social, economic, and ecological drivers that are responsible for the flows among the components of an urban system and the changes in these flows over time.

2.2_A new approach for UM analysis: practices, complexity and emergence of macro-behaviours

UM is the outcome of complex arrays of social practices and activities that change over time and it is a matter of regulation, which requires a decisional perspective. Urban metabolism must be approached as a dependent variable to be explained. Part of this explanation depends on environmental factors independent of human intervention (at least at the urban scale considered). The remaining part depends on an emergent systemic configuration of practices affected by many factors.

Recalling what above introduced, a city is not only a metabolic unit but also a social system. Making sense of the triggers of the metabolism of a city and the way one may apply such triggers, so that metabolism may shift towards greater eco-efficiency, requires a understanding of the political, institutional and cultural factors that affect how a city's use of matter and energy (i.e., its economy) works. To renew the UM conceptual framework two perspectives of analysis must be considered:

- **Regimes of urban regulation.** A mode of regulation is an emergent ensemble of social practices, rules, conventions, patterns of conduct, organisational and institutional forms that can stabilise a metabolic regime. The regulation approach focuses on the 'regularities' (and their disruption and change) one can observe in the functioning of a urban system. A list of regulatory devices should include also what may be called material arrangements and 'sociotechnical regimes', that is, technological artefacts and devices working in connection with households practices or composed in expert systems.
- **Agents and practices.** Patterns of resource consumption mostly depend on daily practices performed by different agents. More than population density or settlement patterns, modes of institutional, organizational and social practices directly affect resources use. Cities generate bundles of social practices that affect resources access and use, often increasing severe social inequalities. Growing groups of people – mainly aged, migrants and alone women – are undergoing difficulties in energy, food and housing access and provision. Phenomena such as food deserts, obesity, scarce mobility, are spreading up with an unusual speed. Recovering, energy and mobility access is also moulded by social position, ageing, income, residence. For all these aspects we can speak of "positional consumption" of resources. The positional consumption not only affects the ways and extents of consumption but also the generation of waste.

More in details, it is worth to underline three aspects related to the study of urban agents' practices:

1. the most relevant factors underlying urban metabolism mechanisms are the practices of household members. Among individual agents at micro level, we consider households neither as isolated units nor as small units of social organization but instead as basic units of an emerging system. Household consumption is ultimately the core of social system reproduction and the research efforts must be oriented in investigating how changes in behavioral patterns at the household level influence other actors.
2. households practices as units of analysis can be regarded as including a variable mixture of reflective choice, unreflective behaviour based both on actual or perceived constraints and on habit or the particular way a space of choice is presented. Choices, incentives and constraints depend on four elements: rules (formal or informal); ideas; socio-technical affordances; and finally money, as a symbolic mediator of relationships capable of affecting the affordability ranking of performances in most (if not all) problem-situations.
3. these elements, in their turn, mediate the relationship among households and the other types of agents, according to their own rationales:
   - for local government actors, we can distinguish three basic styles of action: authority, provision and enabling.

- for corporate actors we can distinguish between: steady (business-as-usual), reactive (behavioural changes according to perceived) and pro-active (changes are anticipated and even promoted).
- for civil society actors we can distinguish between initiatives of a public or private character.

2.3_A new model for UM assessment: objectives and tools

A different conceptual framework calls for different methodological tools. The Input/output models, even in the evolutionary and dynamic version represented by the adoption of a Stock and Flows paradigm (based on System Dynamics techniques) keep the analysis at a high aggregation level (cities or subsystem). This level of observation, even if might provide an accurate description of UM patterns, doesn't allow the needed 'bottom-up' approach that is the identification of the mechanisms that drive the emergence of these patterns starting from the individual practices.

The goal of a renewed UM analysis is in fact to reconstruct the factors impinging on the systems of practices in which actors' behaviour finds its place and the connections between the different types of agents (households and civil society groups, corporate and local government actors) in order to provide effective knowledge to design future climate policies. This means detailing actors, regulatory and institutional configurations, tools of regulation (incentives, rules, socio-technical affordances, information campaigns and other sources of ideas, innovation strategies at the corporate and civil society level) and their significance, identifying the drivers, dynamics, possible conflicts and tensions through which sustainability-related processes are organized, transformed and relationally interconnected.

To reach this objective we currently need to build complex scenarios that explicitly explore the impact of different urban evolutionary trajectories, that can drive the designing of different reasonable policy alternatives. Such scenarios would allow evaluating the social and economic "costs" and "benefits" of long-term climate goals. It is noteworthy that there can be very different ways/policies to achieve low-carbon cities, and these ways cannot be decided by experts and politicians alone but might consider the participation of a wider public of urban actors in providing knowledge so as in evaluating decisions.

Three methodological approach seem to be appropriate to reach these objectives:

Scenarios building via backcasting approach. The backcasting represents a step beyond the conventional scenarios approaches that are mainly based on a 'push model' based on "drivers behind" factors. Backcasting approach is a 'pull model' based on factors of attraction. It is framed as the actual analysis of how to attain desirable futures, i.e. the process of working backwards from a particular future end-point to the present to determine what measures would be required to reach that future. It starts by identifying desirable futures and then looks backwards from that future to the present in order to design roadmaps to achieve it. Backcasting has gradually become more widely applied over the last decade for its strongly normative concept of sustainability. Backcasting works through envisioning and analysing sustainable futures and subsequently by developing agendas, strategies and pathways to get there. This has attracted attention from policy-makers in many countries, as well as scientists outside foresight and sustainability studies.

Agent Based Simulation. Agent Based Modelling is a computational method which adoption in Social Sciences has been fast growing in recent years mainly for its capability in grasp the complex dynamics of social phenomena. Building an ABM means recreating by computer simulation the phenomenon we're focused on by using information and data (provided by official statistics and public engagement) in order to modelling individual behavior (model calibration) and, by running the model, obtain a macro results to be compared with the observed reality (model validation). At the end of this process explanatory model is provided (a possible explanation, not statistical probable) that can be used to forecast, represent different scenarios, verify theoretical assumptions or just describe the observed reality.

Finally, it should be a noticeable improvement (even if not easy neither low-cost to implement) adopting tools for an effective **Public engagement**. This approach may result in a wide range of practices going from the construction of a shared framing of the problems, through the sharing of diffused knowledge to a realized deliberative democracy (e.g. participatory budgeting). The complexity of UM assessment, in fact, calls for this public engagement since it entails an interdisciplinary approach whereas physical, economic and social indicators have to be merged and harmonized in order to draw a picture of UM. The plausibility of this picture is closely connected with the participation of the urban actors above defined (households, corporate actors, public administration and communities) since a shared vision of the UM among the actors is needed in order to mobilize knowledge to better define problems and find effective solutions. A lot of tools have been developed to support this approach but among these tools for public engagement are gaining a central role some practices (more or less formalized) referred to the concept of *crowdsourcing*. Crowdsourcing provides support for managerial decision making, problem solving, and opportunity exploiting. The crowd (contributors or solvers) generates ideas and may also be involved in analysing and prioritizing proposed solutions to problems. To understand the natural, social, and economic frameworks in which resources are consumed it is necessary to involve both policymakers and local stakeholders in urban metabolism research to ensure that planners understand the implications for those who will be affected by their plans.

The general idea to be implemented, thus, is a three-steps methodological process: a) identifying scenarios by adopting a backcasting approach (combined with roadmap designing) for the conceptualization of different trajectories ; b) validation of the scenarios by the engagement of experts, decision makers and wider public; c) operationalisation of the scenarios validated by using Agent Based Modelling techniques. Figure 2 shows, as an example, a simplified scheme of a UM model drawn on the basis of the proposed UM conceptual framework and aimed at defining trajectories to reduce metabolic processes with particular attention on the production of waste.

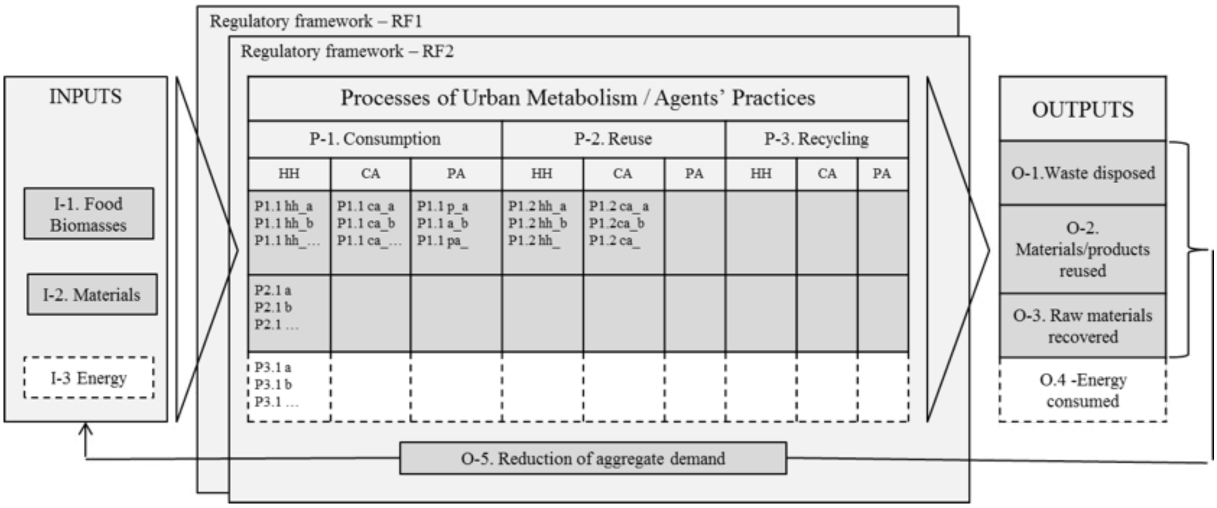

Figure 2. A Conceptual scheme of a UM Agent Based Model.

The model is characterized by few distinctive elements:

a. Individual agents are HouseHolds (HH), Corporate Actors (CA), Public Administration (PA).

b. Individual agents are situated in different Regulatory Framework (RF1, RF2) referred to different institutional and normative context.

c. Individual agents act following different strategies/practices: Consume (P1), Recycle (P2), Reuse (P3). They act all along the waste chains referred to different inputs in the urban system (I1,I2,I3).

d. The cross consideration of strategies and inputs will allow to define different specific practices for each type of agent (labelled in the figure with the alphanumeric code 'p_Input.Strategy_Agent_n of practice') and for each Regulatory Framework.

e. The most important. Even if extremely simplified, the figure clarifies the crucial conceptual element of the framework: the Input-Output flows is decomposed/recomposed from the macro to the micro level and the overall effect in terms of metabolic processes is determined by practices at individual level.

To feed such a model a huge amount of different data are needed and namely: quantitative data form statistical institutional sources, knowledge about current and possible normative and policy frameworks, qualitative information about individual behaviors derived from the engagement of experts and wider 'crowd'.

Once data and information are collected, the design of reasonable scenarios can be carried out by working on the interplaying of the different elements at the di different level of the model: individual practices, norms, amount of inputs and so on. Finally, the implementation in an Agent Based Model will provide not just the description and representations of different scenarios but, more important, some measures of the connected outputs. That is an assessment of the sustainability of alternative policies.

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Sustainable University Campuses

SMART AND SUSTAINABLE TRANSPORT THROUGH UNIVERSITY CAMPUS

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transport strategy

Abstract

One of the main environmental pollution issues inside a large campus comes from the vehicle usage. Where vehicle usage is required and its necessity is more than evident, several solutions for a clean transport must be taken into account. The major on-campus actions to reduce environmental impacts that come from transport activities include policies that highly discourage automobile use and encourage other means of transport like: biking, light electric vehicles, electric conveyors and walking. Starting form designing a modular platform equipped with electric powertrain and intelligent systems that allow autonomous driving, the following approach was developed. For implementing the newly transport system through a university campus, several preparation activities seem to be mandatory. One major boundary may be met from humans' perception. Therefore, the users must be prepared for such a major change. The modular platform can be used as a free public transport system. Designing different routes for light public transport through university campus, the users are connected with the main public transport hubs nearby the university. In addition, being a modular platform, it can be equipped or set out with different equipment needed for inside campus services, like maintenance or sanitation. The electric powertrains are more frequently used nowadays, having the advantages of the newly developed batteries and accumulators. Combining the autonomous driving technologies and the electric powertrain, the project can reach a very high level of development. The objective is to replicate this measure in order to use the modular platform as a campus transport system, but also work inside the city for improving the regional transport systems for the community and beyond.

1_Introduction

1.1_Vehicle development tendencies in terms of sustainability

Mobility is fundamental to our society and economy. It must be sustainable to assure a prosperous future for everybody. While supporting economy, meeting travel needs and ensuring a long-term viability for the transport systems, the natural environment needs preservation for mobility upgrade. The revolution of the mobility will be assured by vehicle electrification and autonomous driving. Local administrations and governments all around Europe must be well-prepared for the changes that will be initiated by the fast developing technological fields in order to gain a maximum benefit towards sustainable mobility.

During recent years, a significant interest in hybrid electric vehicles (HEV) and more and more in electric vehicles (AEV – all electric vehicles) has grown globally due to the environmental concerns and the limited availability of fossil fuels. A new trend in vehicle design, hybrid vehicles surfaced in many different ways. The hybrid powertrain can combine multiple different power sources of different nature: conventional internal combustion engines (ICE), internal combustion engines that use unconventional fuels (CNG, LPG), batteries, ultra-capacitors or hydrogen fuel cells (FC). These vehicles with on board energy storage devices and electric drives allows braking energy to be recovered and reintroduce it into the system and ensures the ICE operates only near the most efficient mode, thus improving fuel economy and reducing pollutants and acoustic noise. In addition, futuristic tasks are also taken into account. The autonomous driving represents another key element that will revolutionize the future mobility while providing various options to address and implement the main aspects of sustainability.

The autonomous driving represents another important development that is meant to increase the possibility for the mobility management dimension. The vehicles' users will benefit substantially from using autonomous driving systems since they gain more freedom of individual mobility and they have the option of spending the time with other tasks while the vehicles are self-driven. (2)

The combination of the two technologies, electric vehicles and autonomous driving, offers a promising possibility to achieve viable innovative solutions towards sustainable mobility. The mobility of the future will provide various options to address and will implement the main aspects of sustainability.

1.2_Environmental Concerns

The United Nations estimated that over 600 million people in urban area worldwide were exposed to traffic-generated air pollution. Therefore, traffic related air pollution is drawing increasing concerns worldwide. Hybrid electric vehicles and electric vehicles hold the potential to considerably reduce greenhouse gas (GHG) emissions and other gasses pollution. ICE based hybrids, can improve the fuel economy and reduce tailpipe emissions by more efficient engine operation. The improvements come from regenerative braking, from deactivating cylinders when no needed power is produced, from shutting down the ICE while stationary and from allowing a smaller, more efficient engine which is not required to follow the power at the wheel as closely as the engine in a conventional vehicle has to accomplish.

All in all, usage of electric vehicles instead of vehicles that use only ICE may reduce de CO_2 emissions during next years. Worldwide, the emissions can be reduced up to 75% by 2050 from the usage of electric vehicles instead of regular ICE vehicles.

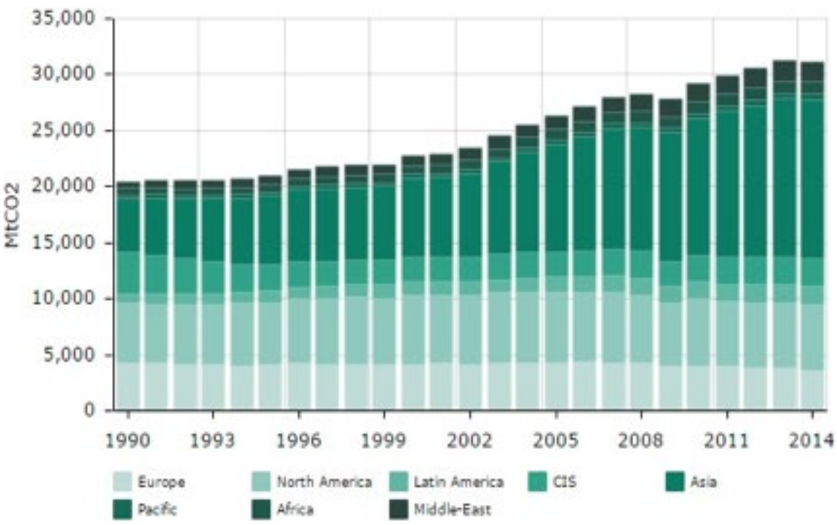
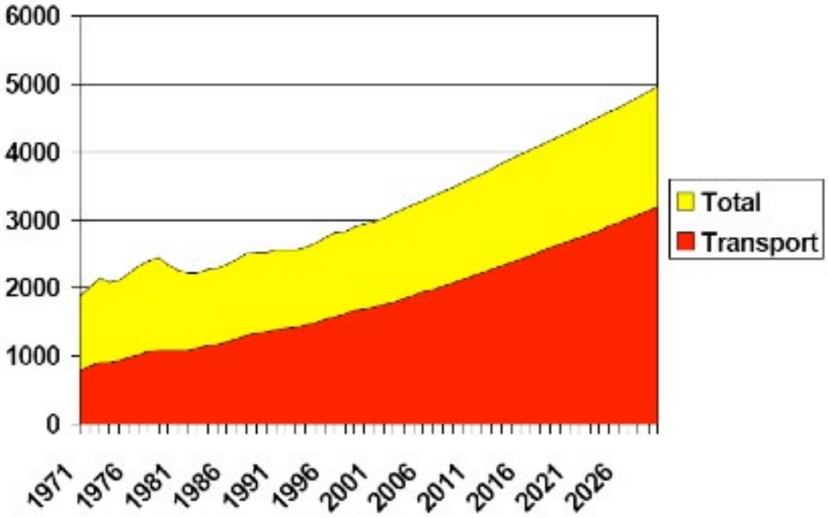


Figure 1. Global CO_2 emissions by country (6).

1.3_Energy Consumption

Around the world, strong upward trend in oil demand and tight supply is noticeable. Maintaining a secure energy supply becomes an on-going concern and a high priority. The US Department of Energy (DOE) states that over 15 million barrels of crude oil are being consumed in the nation of which 69% are for the transport sector. The transport energy consumption worldwide are also continue to rise rapidly. In 2000 it was 25% higher than in 1990 and it is projected to grow by 90% between 2000 and 2030 as shown in Figure 1.

Figure 2. Global Oil Consumption Perspective (5).



2_Project Motivation

University 'POLITEHNICA' of Bucharest is one of the biggest universities from South-Eastern Europe. It hosts over 25.000 students and spreads over a big area with extensive green spaces, walking areas, sport courts and many other facilities. With so many open spaces comes big distances to cover while walking, even while using vehicles. Some of the students and professors use their personal cars to move around, but this solution brings other disadvantages like the pollution from exhaust gasses of green areas, noise pollution and at last but not the least, using private cars inside the campus increases the risk of accidents. Another possibility to facilitate the inside campus transport consists in using shared bikes, but they are limited. Unfortunately, no others means of public transport inside the campus are available.

While trying to elaborate a solution by linking the three main access points which are connected to the city public transport system, several constrains are taken into account. Students and professors find difficult to cover the route from two different points of interests during limited time or during bad weather. The presented approach excludes the possibility of using conventional minivans or minibuses that are source of pollution and present security issues during operation. While developing innovative powertrain equipped with electric machines and rechargeable batteries, in addition to advanced driving automated systems, the new mean of transport is dedicated to cover most of the transport demands (1). The goal of this approach is to implement the private car independent lifestyles inside the University Campus and to use dedicated light vehicles.

3_Vehicle Design

The light electric vehicle is basically designed on a modular platform that can operate **autonomous** (1). The level of autonomy represents an important challenge; the vehicle is set to reach velocities not more than 10-15 km/h, the possibility of an accident being limited.

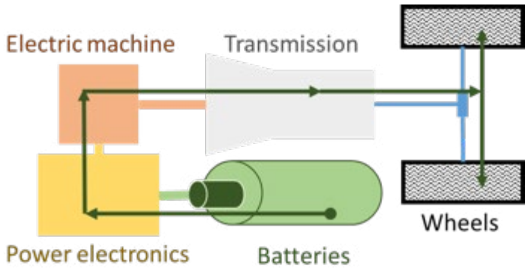


Figure 3. Electric Vehicle Architecture.

3.1_Electric powertrain overview

The electric powertrain system is covering more and more vehicle solutions, through the newly developed batteries and energy storage devices. The main parts of such propulsion system are the electric machine, the transmission, the power electronics and the high voltage batteries (figure 3). These main parts will be designed for fulfilling vehicle requirements.

3.2_The structural frame

Powertrain electrification involves redesigning the chassis as an essential part of the vehicle. After several researches regarding the frame that can be used for this light electric vehicle, the most suitable one is based on the 'Space Frame' constructive solution. This solution can be easily integrated for electric vehicles.

The objective is to develop the structure as a modular platform that provides the ability to use the same components and modules for different types of vehicles. These similarities lead to reduced costs despite the relatively small number of developing each vehicle separately. (1) The chosen design has several advantages. Its modularity allows easily adapting to different solutions and different sizes needed for additional components. The inside volume space can be used for housing the battery package and the power electronics, offering high protection in case of accident. (3)

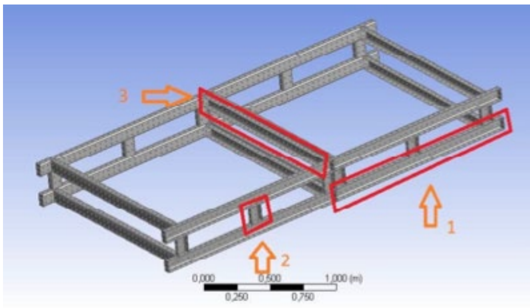


Figure 4. Isometric view of the structural frame (3).

3.3_Autonomous driving

The proposed vehicle will be autonomous driven, being able to develop the speed not more than 10 km/h, as established by "Vienna Convention" (1968) and "Geneva Convention" (1949) regarding the road traffic regulations to allow vehicles to be driven autonomously on public roads. The in campus use can accept some exceptions, but only for testing the equipment.

4_Project Implementation

4.1_Vehicle Destination

The project will bring huge social benefits to the University Campus, to the students and professors, to the employees and last but not the least to visitors. The project intends to use this platform mainly as a free transport solution.

The pilot project consists in using a light electric vehicle with nine independent seats. The vehicle will facilitate the transport from the three main transport hubs nearby the university campus. The vehicle schedule will closely follow the working hours. It is obvious that not only one vehicle can sustain the transport of more than 25000 users, but the pilot project target is to show the success of this opportunity and the challenge in the same time.

The designed light-autonomous-electric-vehicle will be used mainly as a light public transport vehicle during the winter and summer semesters. Other design solutions are taken into account. The solution using a water tank and hoses can be used for the maintenance of the green areas during summers; while during winter, the vehicle can be redesigned to be equipped with different components, like razorblades, to remove the snow from the roads and removing ice from the pedestrian paths. Another solution consists in adding dedicated equipment for the hot summer days that acts as a water cooling system and offers free cold water. The light-autonomous-electric-vehicle can also be equipped as a light garbage vehicle that collects waste over the university.

4.2_Impact

The light-autonomous-electric-vehicle will have a huge impact on the entire university community. The students will benefit from a free transport method, but also they will learn about the utility of non-conventional propulsion possibilities. Therefore, the project will have also social outcomes and valuable feedback concerning the acceptance for the autonomous technology implemented on vehicles for public usage. Nowadays, the progress of technology is very fast increasing and there is a chance that population cannot keep up; therefore, people are not used to rely on autonomous driving.

Being autonomous, the vehicle will represent an innovative solution by the means of transport inside the university campus. Being a driverless vehicle, this mobility solution can have its reasons of doubt from the users. Among part of the users, it will be a well-accepted and, moreover, appreciated. Though, another category of users can be reserved in using this type of transport. Despite this fact, it will be advantageous for them because they can enjoy an effortless ride.

The light autonomous electric vehicle has to increase the awareness to non-conventional propulsion system and also to the safety measures that can be taken by the autonomous driving feature. From the pilot project to a large scale implementation, the community behavioural responses are mandatory. Taking into account both less pollution and increasing confidence in operation for the newly transport solution, the impact represents the major focus. The project will attract huge interest in the new era of non-conventional propulsion for vehicles and of autonomous vehicles.

4.3_Work Plan

The pilot light autonomous electric vehicle solution will be desired mainly for the public transport.

The available infrastructure allows taking into account three transport hub stations, representing the main points of access to the university campus, as shown in the map Figure 4. The three points of access are linked to the city public transportation system, being set as picking-up stations. One of the station will be close to "POLITEHNICA" Metro Station, and the other two will have access to the city busses (numbers 601, 336, 236, 136, 62, 61), from Iuliu Maniu Boulevard and from Splaiul Independentei Boulevard.

In the first development phase, the project approach includes six vehicles that will cross the area from the picking-up stations to the destinations set by

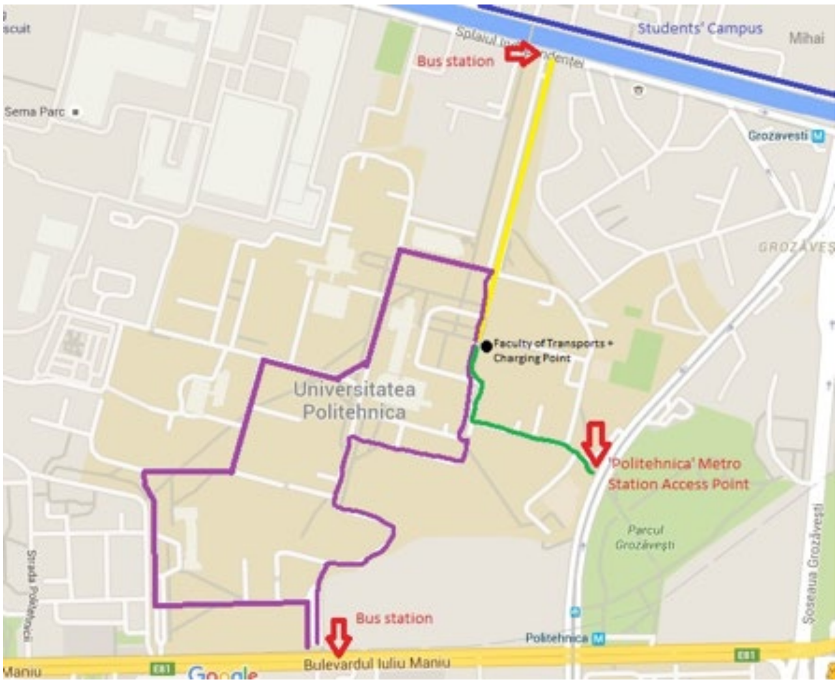


Figure 5. The main three access points inside university campus.

the transport route. The light autonomous electric vehicles will be scheduled within fifteen minutes interval. The routes inside the university campus are shown in Figure 5.

The needed electric energy will be provided by the charging point that is settled nearby the Faculty of Transport, shown in Figure 5, where the university has an electric charging station that can successfully maintain the need of electric power of six vehicles. The charging operations will be done by night, when all the vehicles will perform autonomous charging from the public grid.

The project is dedicated to the entire university community, the treated subjects being multidisciplinary. The implementation and maintenance of the electric components is done by multidisciplinary teams, including members from different faculties, while the in deep research target is to reach a higher level of autonomy in driving.

Figure 6. Charging point in front of Faculty of Transport.

5_Conclusions and discussions

Still, electric vehicles and e-mobility services have low usage among communities. One of the aims of the project is to increase the awareness of needed zero-emission vehicles. The new technologies and solutions are meant to increase the users' confidence on e-mobility.

This pilot project aims to show what positive impact will have the integration of light autonomous electric vehicle inside and through a community.

The potential of replication of the transport solution is high: it can be replicated to small cities transport system, community service intelligent vehicles, city centers tours transport or exhibition transport.

The project has its own risks. The possibility that this vehicle will not be accepted by the potential users is a strong debated subject. Being a new concept, the light autonomous electric vehicle might not be trustworthy, and the population will not want to rely on a vehicle that has autonomous driving capabilities. From this point of view, a new risk appears that the programming dedicated to the autonomous driving system will be hacked by bad intended people and an accident may occur, which will be a major problem for the project.

Several boundaries regarding the available roads for the testing phase can be taken into account, while restricting the private vehicle access inside the campus can irritate several people. Technological boundaries can be also met during research activities.

The project will represent a great step forward when it comes to technology and technology development inside university campus, inside the town and to our country.

6_Future work

The researched solution is set to be easily replicated to other areas, including urban city centres, supermarkets, large construction zones, out door and in door exhibition areas, museums, and why not, protected and restricted areas (military bases, airports etc.). In addition, other multiple activities are taken into account to be performed by this modular electric vehicle, being just a matter of testing for implementing and validating the solutions. (1)

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BESPOKE APPROACH FOR MAINTENANCE MANAGEMENT OF FACILITIES AT NIGERIAN PUBLIC UNIVERSITIES

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Abstract

In Nigeria, most public universities are currently under pressure to preserve their respective built environments. The poor states of facilities on campuses of public universities has been the concern of stakeholders of these institutions because, the facilities are no longer able to support academic activities as they did decades ago. Several factors may be blamed for the deteriorating states of the facilities. However, most of these factors may be directly or indirectly related to maintenance management systems in use by the maintenance managers. In this paper, a bespoke approach for an effective maintenance management system for facilities at public universities in Nigeria is proposed. The paper is based on theoretical understanding of maintenance management and previous research findings about the deteriorated states of facilities and an insight into the maintenance management systems that are currently operated at the public Nigerian universities. It is noteworthy that there are no policies/strategies that guide maintenance activities of the departments/units saddled with such responsibilities (strategies cannot be developed in isolation of any impact factors). In addition, gaps exist between the top management staff that have the decision making and planning skills and the on-site operations staff that carryout the maintenance task on site. The need for proactive approaches for facilities at the Universities is an important drive towards sustainable campuses.

1_Introduction

Establishing universities is prioritised on development agendas of most former colonial countries, because of the perceived importance of human resource development and perceived national prestige (Adesina, 2006). In Nigeria, the society looks up to the universities for essential knowledge and skills that are required for improvement in the quality of life and the sustenance of the economy (Kazeem & Ige, 2010). These institutions play very important role in building and sustaining developments in the nation, and most times they form part of committees or organisations that lead sensitive international corroborations on behalf of the country. For instance, the United Nations' (UN) Sustainable Development Solutions Network, (SDSN) launched its Nigerian branch in 2013 in consortium with Nigerian universities. The SDSN-UN was launched in 2012 with a primary objective of promoting practical approaches to solving sustainable development Goals. SDSN-Nigeria outlined key objectives that include:

"Promote sustainability as a way of life in all spheres of activities within the university, in infrastructural and physical development, care of the environment, and promotion of individual and collective behaviour consistent with concern for the future of the planet" (SDSN-Nigeria, 2015).

This objective touches on issues that relate to sustaining physical environment, thus, it becomes imperative for Nigerian universities to ensure that this objective is addressed on their respective campuses to enable them lead or help other communities in achieving same efficiently. A good starting point is to rethink maintenance approaches that will salvage the existing campus facilities because, there is a growing concern about the deteriorating situation of built facilities on campuses of many Public universities in Nigeria. This is in line with research works reports that affirm that facilities provided at many public universities in Nigeria are in a state of structural disrepair (Abigo, Madgwick, Gidado, & Okonji, 2012; Adamu, 2015). Ineffective maintenance approaches is identified to be a major factor responsible for the gross disrepair (Omoregie, Ebohon, & Radford, 2005).

In this paper, the term 'facilities' refers to all built assets that make up the built environment. Universities are responsible for providing facilities to cater for academic (teaching and research) activities on their respective campuses. Some ensure that residential facilities are provided, for both student and staff on campus (Pat-Mbano, Alaka, & Okeoma, 2012, Adamu, 2015). These facilities are the most valuable assets of universities after the students and staff (Pat-Mbano, Alaka, & Okeoma, 2012). This is factual because, adequate provision and effective maintenance of facilities on campus creates enabling environment for smooth running of academic activities (Idrus et al., 2009).

2_Maintenance in the Context of the Built Environment

"The built environment expresses in physical form the complex social and economic factors which give structure and life to a community. The condition and quality of buildings reflect public pride or indifference, the level of prosperity in the area, social values and behaviour and all the many influences both past and present, which combine to give a community its unique character. There can be little doubt that dilapidated and unhealthy buildings in a decaying environment depress the quality of life and contribute in some measure to antisocial behaviour" (Lee, 1987).

Moreover, the condition and quality of a built environment is a major factor that determines the quality of life, because people spend over 95% of their time around building structures (Wordsworth & Lee, 2001). Over 90% of university activities are conducted within the built areas of the campus. On a second note, the condition of the built facilities reflect the well-being of the university community and their productivity (Lateef, 2010). The role of maintenance managers in preserving the built environment cannot be over emphasised. However, the maintenance management is perceived to be a complex undertaking that is often associated with wide difficulties in planning and executing tasks (Marquez & Gupta, 2006). Therefore, maintenance managers require adequate knowledge of the concepts and principles of maintenance management in tackling these challenges. This is in addition to operational and functional knowledge of the facilities.

The term maintenance is defined as "combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to a state in which it can perform the required function" (CEN-EN, 2010). Maintenance management of facilities is concerned with efficient utilisation of resources (material, labour and time) towards meeting certain sustainable and value adding needs such as reliability, safety, and functionality of built facilities (Idrus, Khamidi, & Lateef, 2009). Combination of technical knowledge of the facilities and maintenance management enables the developing an effective maintenance management frameworks. An effective maintenance management system must be consistent, proactive and holistic (Abdul Lateef, Khamidi, & Idrus, 2011). Maintenance requirements are comparatively demanding, because multiple tasks are involved; moreover, the effectiveness of a maintenance approach largely depends on the managerial procedures (Hon Yin Lee & Scott, 2009).

2.1_Conceptual Framework of Maintenance Management

Maintenance approaches in many organisations, particularly in the manufacturing industry has been evolving for over ten decades. The decennial trend have been discussed in maintenance related literature (Dunn, 2003; Pintelon & Parodi-Herz, 2008). These studies attest that maintenance function is no longer a mere technical function but a strategic issue that requires strategic management skills in operating and maintaining facilities optimally. However, the perceptions and approaches of maintenance in the building industry has experienced very little change, therefore innovation is scarce in facilities maintenance management, especially in relation to the building industry (Cloete, 2001).

The term 'maintenance management' combines two important and distinct functions viz. operational and managerial. The range of skills required for operational functions is very different from those required for managerial input. The operational aspect requires purely technical skills, while the managerial deals with decision making, precisely "what and how to decide"(Pintelon & Parodi-Herz, 2008). A combination of non-technical and technical approaches in many management based systems is important in achieving an effective and efficient management system (Leong, Zakuan, & Saman, 2012).

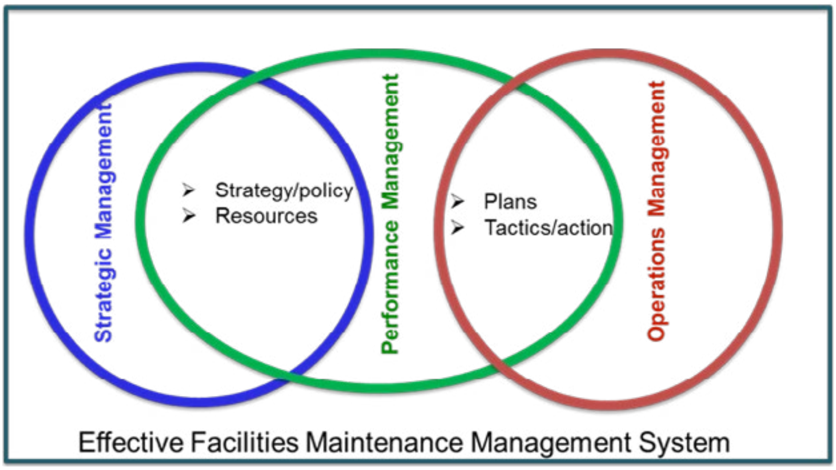
Maintenance management is a goal-driven process that requires basic management principles to plan and execute maintenance works efficiently. A sustainable maintenance management system engages strategic management activities that revolves around data collection, strategy formulation and evaluation, programme selection, implementation and feedback (Idrus, Khamidi, & Lateef, 2009). In line with this, strategic and performance management are major aspects, which require understanding and consideration in the maintenance management of built facilities (Hon Yin Lee & Scott, 2009). These distinct but interrelated aspects of management focus on supporting main objective of the organisation, which is linked to the mission and vision of the organisation. Therefore, accurate perception of the mission and vision of an organisation supports its ability to set appropriate maintenance standards and policy for the maintenance operations of its facilities.

Operations management functions consists of various tasks to be executed in accordance with a maintenance policy/strategies developed by strategic management (Marquez & Gupta, 2006). This is necessary for achieving the maintenance objectives as set by an organisation for maintaining a facility and its associated services (Lateef, 2010). The basic tasks in this process are corrective or preventive operations; where the former refers to all activities undertaken after the occurrence of a failure, while the latter refers to activities in anticipation of a failure occurring (McLean, 2009). The execution of maintenance tasks involves one or a combination of the following activities; service, rectification or replacement (Buys, 2004).

The enormous task of developing and implementing a maintenance system for built facilities on a university campus is beyond the skills of technical staff (tradesmen such as carpenters and electricians) that diagnose and carryout most maintenance works on university facilities. Therefore, an excellent practice of maintenance management is greatly needed to increase the life cycle of the property and to minimise unexpected breakdowns or deterioration effects. In this respect, modern maintenance managers will have to rely as much as possible on knowledge and practical management skills to carry out maintenance tasks efficiently (Zulkarnain, Zawawi, Rahman, & Mustafa, 2011).

Figure 1 presents the authors' conceptual framework for an effective maintenance management of built facilities developed from articulated theories that underpin maintenance management. The framework is depicts three rings that interlock within a universal set represented by the rectangular shape.

Figure 1. Conceptual framework for facilities maintenance management.



The conceptual framework draws inspiration from the fact that maintenance strategy developers and managers are usually at one end of the spectrum. On the other end is the operations management team that are active on the physical maintenance site. Although skills required for strategic management differ from that of operations or onsite work management, there is need to establish a link between the two functions to enable focus on a single maintenance goal. Performance management is found to be an ideal function that would serve the purpose of transforming strategies/policies in relation to resource availability to develop plans of action for maintenance operations.

3_Establishment and Structure of a university campus in Nigeria

All universities in Nigeria that were established from 1960 (National Independence) to early 1980s (economic prosperity period) were solely owned by the Federal Government of Nigeria (FGN); therefore these institutions were on an exclusive list of the FGN to receive funds and management support (Ajayi & Ekundayo, 2008). The campuses were designed and constructed on extremely large expanses of land, far from main towns or cities with provision to house both staff and students; and intended to be self-sufficient communities (Esenwa, 2003). Facilities in the universities

were adequate and furthermore, they received pre-requisite maintenance because there was sufficient funding from the FGN (Ikediashi et al., 2012).
Basic infrastructural development on campuses of most public universities in Nigeria and utility services include:

1. Classrooms, workshops, laboratories, ICT centres
2. libraries;
3. student and staff residences;
4. clinics/health centres;
5. worship centres (churches and mosques);
6. student centre, staff club;
7. sports and gymnasium;
8. market/shopping centres, banks, eateries, security posts;
9. electric power and water supply, road networks, street lighting and illumination and landscaping

(Adamu, 2015; NEEDS, 2012; Uche, Okoli, & Ahunanya, 2011).

Many State Governments (SGs) in the country have established universities and private-owned universities too have emerged because the FGN is currently experiencing difficulties in providing university education for the nation’s teaming populace. However, all universities, are faced with managerial challenges within a very unstable socio-economic environment(Arowolo & Ogunboyede, 2013). Although, the public universities are still fully dependent on FGN for capital expenditure as well as supporting recurrent expenses incurred, these have drastically reduced and the senior management of the respective universities are forced to operate within tight budgets (Olaleye, 2012). The situation is blamed on the continuous increase in the intake of students with every academic session despite an increase in the number of both public and private universities established to date and ineffective management strategies/policies (Adamu, 2015; Akingbohungbe & Akinluyi, 2012; Ojedokun, Odewumi, & Fasola, 2012).

4_Maintenance management framework for Nigerian Public university facilities

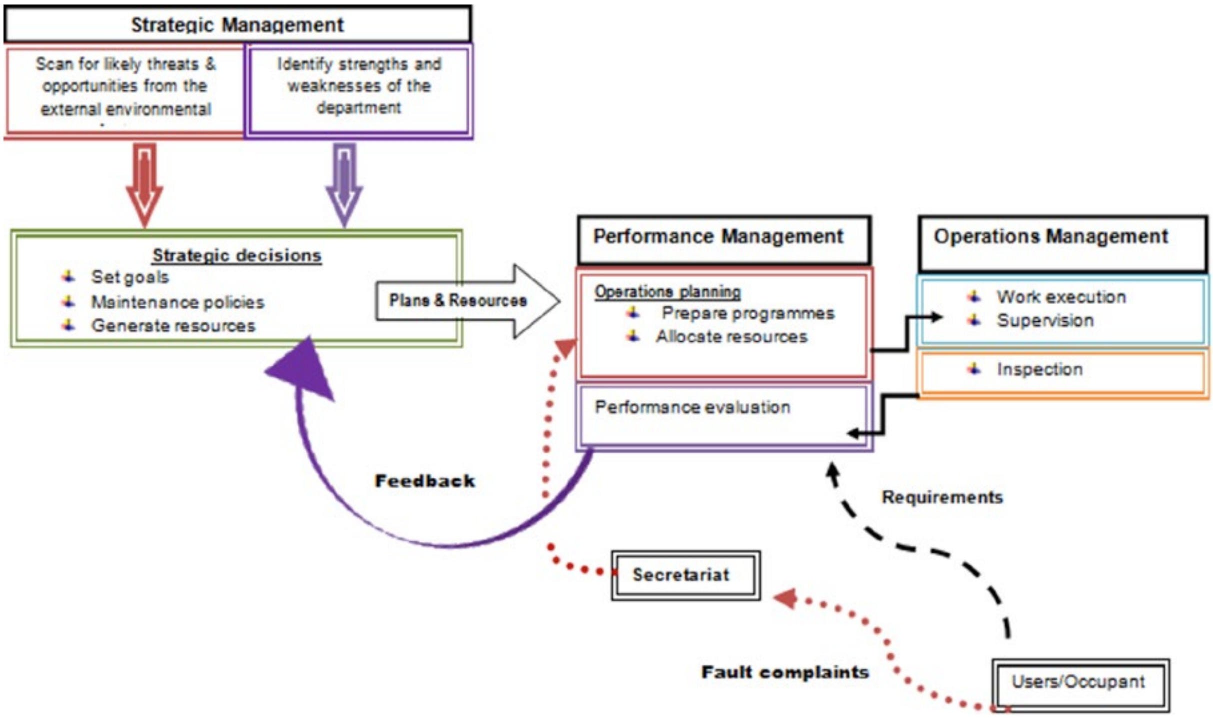
Maintenance management of the built environment of a university is an important service that must be afforded the desired attention by top management. The effectiveness of the maintenance management system has an impact on the condition of the buildings and in turn, the health and safety of staff and students that occupy or operate the facilities. These facilities support the core business of a university establishment none other than research and dissemination of specialist knowledge for the purpose of socio-economic development.
An effective maintenance management system integrates the principles of strategic management, performance management and operations management. However, the maintenance management processes for all the public universities studied have no strategic focus because no strategic planning activities are carried out to understand the nature of the facilities, their use and nature of failure or maintenance requirements. Adequate and higher level of understanding of the value and positioning of maintenance would

necessitate the development of an effective maintenance management approach for built facilities.

The framework was developed, firstly from the articulated concepts of maintenance management from the literature and the gaps in the systems obtainable at the surveyed institutions. Secondly, from an understanding of current condition and the maintenance systems in place the public universities studied.

The framework is presented on Figure 2. The framework depicts three main aspects of management that are involved and describes the responsibilities and span of control.

Figure 2. Maintenance management framework for built facilities at public Nigerian Universities. Source: Adamu, 2015.



The framework is based on the principles of strategic planning and decision-making. There are three management components that are major actors in the process. The process is described in the following sections.

4.1.1_Maintenance Strategy Formulation

The managers at this level are required to be construction and property professionals that have strategic planning skills and experience. Knowledge and skills of construction and facilities management will be of great advantage to the team. The plan of action for the maintenance strategic management function is based on a structured planning method popularly known as the 'SWOT analysis' (Strengths, Weaknesses, Opportunities and Threats). The stage begins with identifying the external environmental factors that are perceived to have major impact on the maintenance of the facilities. The behaviour or changes in the factors can either have positive or negative impact on the maintenance system. Identification of the environmental factors (both internal and external) sets the parameters within which maintenance is to be managed; and their analysis provides a clear basis for forming maintenance objectives and consequently, the planning and control of maintenance .

Those factors that have positive impact are regarded by managers as opportunities, for instance, improved infrastructure or boost in the economy. The factors that have negative effect are regarded as threats to the system, for instance, poor government policies or their implementation; increase in the population of students could be considered as threat to effective maintenance. In Nigeria, certain economic factors (domiciled within the external environment), e.g. drop in the oil price (national recession) has been a major harmful factor on the internal finances of the universities (given that all public universities in Nigeria depend on Federal Government of Nigeria for disbursements) which in turn affects the budgetary control of maintenance (making planning even more crucial). Maintenance strategic managers are saddled with the responsibilities of formulating and re-formulating maintenance strategies.

4.1.2_Strategy Implementation

The developed and evaluated strategic plans are executed at this stage. The implementation process involves carefully allocating roles and responsibilities among managers (typically through the design of the organisational structure), allocating resources, setting short-term objectives, and designing the organisation's control and reward systems (Hill & Jones, 2012; Tse, 2010). Strategy implementation includes developing a strategy-supportive culture, creating an effective organisational structure, redirecting marketing efforts, preparing budgets, developing and utilising information systems, and linking employee compensation to organisational performance (David, 2011). Maintenance performance managers at this stage must have adequate understanding of the maintenance strategies handed over to their unit by the strategic managers. Based on the strategies formulated, the performance managers develop operations plans for the effective implementation of the strategies. Furthermore, maintenance programmes could be prepared to guide the actual work execution by the operation managers.

4.1.3_Strategy Evaluation

At this stage, effectiveness of the strategy is evaluated to locate shortfalls of the plan for necessary adjustment or change where the desired results are not achieved (Tse, 2010). A feedback mechanism must be established between the operations managers that execute the maintenance works to the performance managers and in turn, the strategic managers. Information about the efficiency of a strategy may be improved or re-formulated by the strategic management team as the case may be. Consistency of the cycle is necessary for a sustainable university campus that will continually support academic activities.

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ENERGY EFFICIENCY IN A LARGE UNIVERSITY: THE UNITO EXPERIENCE

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Abstract

The University of Turin (Unito) counts over one hundred buildings in and around the city of Turin. Unito's stock includes buildings with different architectural features and functions: from historical XVIII century buildings to the splendid new Campus Luigi Einaudi.

In 2015 a thorough review of Unito energy consumption was started, The review has exposed several issues: the inhomogeneity of data sets, the lack of tools for data visualization and analysis, the lack, for historical sites, of modern equipment for an efficient management and, finally, the inadequate user awareness about sustainability issues. In the absence of centralized tools for building automation, the first steps to improve energy efficiency require a detailed work in collaboration with the users. For this purpose an interactive web application has been developed. Starting from historical consumption data, several cases of energy waste have been identified: reactive energy, off-hours lighting, sub-optimal heating and air-conditioning schedules etc.

Online Open Data tools and real-time monitoring can also improve users' awareness and their engagement in sustainability, and support the energy management of large building stocks. Due to the heterogeneity of its building's stock, the experience at Unito might be representative and is susceptible of generalizations at the district level.

1_Introduction

In the last decade the European Union (EU) has started the long path to reduce the Green-House-Gas (GHG) emissions, adopting various environmental measures in the context of the celebrated 20-20-20 policy. There are of course various ways to reduce the consumption of fossil fuels and to better manage our resources. One is to expand the use of renewable energy sources, another is to increase the energy efficiency, through structural changes on existing buildings, improvements in the way energy is managed, and by rethinking our lifestyle. Indeed, residential and service buildings are responsible for a large part of primary energy consumption: in the EU this is about 40%, more or less half of which is spent for indoor climate conditioning. (Poel et al, 2007) (Balaras et al). In the following we describe the general approach we have followed to identify and reduce energy wastes, together wih a few preliminary results obtained in our approach to energy auditing in a large buildings stock.

1.1_University of Turin Building Stock

The University of Turin (Unito) manages 120 different buildings in the city of Turin and in the surroundings, for a total of almost 550000 m^2. It has more than 67000 students (62% women, 38% men), about 2000 professors and lecturers and almost 2000 administrative and technical staff. The annual expenditure for energy amounts to almost 10 million €, corresponding to 23.5 GWh of electrical power, 2.08 TOE of gas and a minor quota of other fuels.

Unito's stock is intrinsically heterogeneous. This causes various problems to the energy and logistics management, mainly because of the different

architectural features, the disparate functions of the buildings, and the varying technical equipment.
First, for what concerns the different functions, Unito includes libraries, administrative offices, educational and research centers, museums, hospitals, convention centers, stables, a botanical garden and so on, with intrinsic differences in management. For instance, hospitals never close, while administrative offices, libraries and museums follow standard day-time opening schedules; the timetable of the Departments depends on the field: for ex., humanities Departments have classical working schedules, while the science Departments hosting laboratories sometimes have to be kept open, at least partially, day and night.
Second, the buildings in Unito's stock were built in different historical period, and have completely distinct architectural features. For instance, buildings in the city centre go back to the XVIth and the XVIIIth century. This is case of the Rettorato (1713), the Maths Department at Palazzo Campana (1675), the administrative offices at Palazzo degli Stemmi (1683), Buildings in the Science cluster, close to the Valentino Park, were generally built at the end of the XIXth century, though many of them were renovated after the World War II, due to bombings. There are also newer buildings, from Palazzo Nuovo (1966), which hosts the Humanities Departments, to the buildings in Grugliasco (1999), up to the newest Campus Luigi Einaudi built in 2012.
This dishomogeneity affects any type of normalization and possible comparison among consumptions for different buildings. The first effort has therefore been to collect all the available data, to test a few general methodologies and to develop online web tools for fast analyses.

2_Data Mining

In next subsections, we report a few case studies, methodologies and results. All datasets derive from a data mining process. They have been obtained in different ways: reactive energy and time-of-day consumption data have been taken directly from the electrical bills, suboptimal HVAC schedules and off-hours lightings data have been obtained from the Control Room of the Campus Luigi Einaudi, which has a Siemens Building Energy Monitoring System (BEMS) named Desigo Insight and, finally, electric loads have been measured directly using electric current monitors.

2.1_Working-hours and off-time consumption

A preliminary investigation has concerned the day and night electricity consumptions. The Italian law adopts time-of-day metering, dividing the day into three time slots, called F1, F2 and F3 and priced differently. F1 corresponds to 8:00-19:00, Monday to Friday, F2 corresponds to 7:00-8:00 and to 19:00-23:00, from Monday to Friday, and 7:00-23:00 on Saturday, while F3 corresponds to 23:00-7:00 from Monday to Saturday, and to the whole Sunday as well as holiday days. Due to the different rates, the electricity bill reports consumption for each time slot. Their comparison can quickly reveal inefficiencies in the lighting and heating schedules. A ratio (F2+F3)/F1 equal to 1 means that the average consumption during working hours is the same as the consumption

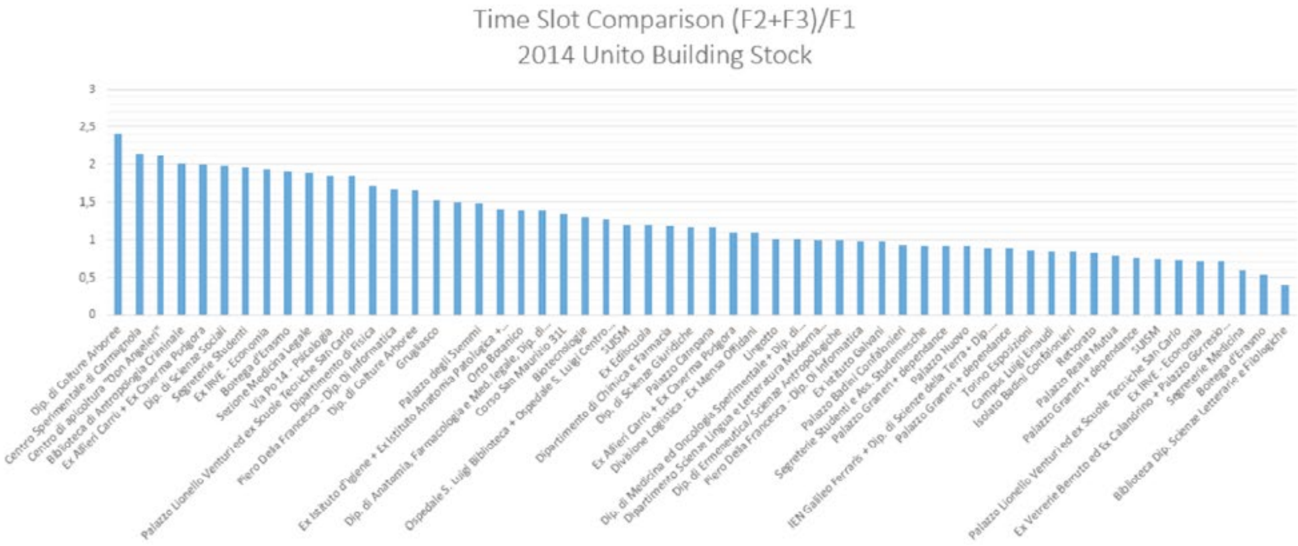


Figure 1. Daily Vs Nightly consumption for Unito's stock. (F2+F3)/F1 ratio represents how consumptions are distributed between working day, night and holiday.

during nights and Sundays/holidays. Figure 1 shows that there are some buildings which during nights and holidays use more than twice the power than during working days. Of course, one should keep in mind that the working hours (F1) represent annually only about a third of the total time. One should also consider the buildings' function: for some sites like Biotechnology, the Physics or Agrarian Department, the high (F2+F3)/F1 ratio is due to technical equipment that works 24h/24h every day. However, for the Administration building (ratio = 1.97), or the Anthropology library (ratio = 2.01) a ratio greater than 2 suggests some problems in the schedules of lighting or heating.

2.2_Reactive Power

Reactive power is defined for alternating current (AC) electrical systems; it is due to the change of phase in the electrical current caused by capacitors and inductances in the electrical loads (Sauer, 2003).

The Italian law (art. 9.1 AEEGSI ARG/elt 199/11) defines the amount for the reactive energy penalty, based on the phase difference j between current and voltage due to capacitive and inductive loads (Musciagna, 2011)

$$\cos\varphi = \frac{E_a}{\sqrt[2]{E_a^2 + E_r^2}}$$

where E_a is the active power, and E_r is the reactive one. The percentage of reactive over active power for 0.9 < cos j < 1 is between 0 and 50%, if 0.8 < cos φ < 0.9 between 50% and 75%, if cos φ < 0,8 is greater than 75%. According to italian regulations, for each kvarh (V*A) between 50% and 75% of the active power consumers must pay 3.23 cent/kWh (Low Voltage) or 1.53 cent/kWh (Medium Voltage), for reactive power beyond 75% of the active energy 4.21 cent/kWh (Low Voltage) or 1.89 cent/kWh (Medium Voltage).

The computation of possible penalties due to reactive energy can be easily implemented and, in the case of the University of Turin, the total penalty during the year 2014 (for 9 months) has been 8282€ as shown in Table 1. Reactive power exceeding the limits can be cheaply reduced by installing a reactive compensation near the load.

Major Reactive Energy Fine - Cost (€)		
Building Name	TOTALE $50\%E_a<E_r<75\%E_a$	TOTALE $E_r>75\%E_a$
Lingotto, via Nizza 262	3207,30	256,99
Ex Edilscuola, via Quarello 11	1475,56	0,00
Ex Alfieri Carrù / Caserma Podgora, via Giolitti 23	1162,69	371,63
Ospedale Molinette, via Santena 9	461,91	0,00
Ex IRVE - Economia, via San Marino 10	446,36	0,00
Total Major Penalty	6753,8223	628,614
Rest of Unito	780,5039	119,9016
Total of Unito	7534,3262	748,5156

Table 1. Main penalties due to reactive energy at Unito.

2.3_A case study: Campus Luigi Einaudi

In this subsection, we describe the preliminary investigations regarding the new Campus Luigi Einaudi (CLE). They involved several aspects, from overall electrical consumption, to more detailed studies computers, coffee vending machines and lighting. First of all, Figure 2 shows the total electrical consumption related to one of the four transformers serving CLE, which supplies the D3 and D4 building inside the Campus. In particular, a very small difference between night and day consumptions is observed. In fact, the difference in the average power absorbed at night and during the day is less than 20kW, which corresponds to a reduction of 14% during the night. This possible sign of inefficiency has prompted an electrical audit on building D3 and D4.

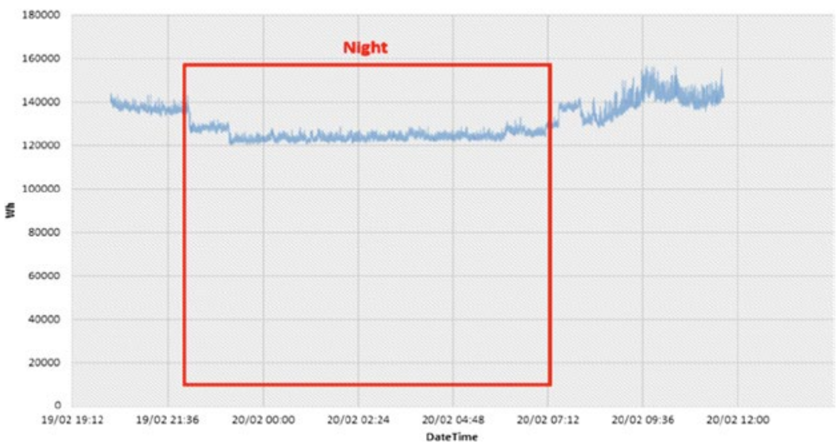


Figure 2. Total electrical consumption for two buildings of Campus Luigi Einaudi. The difference between night and day consumption is less than 14%.

2.3.1_Suboptimal heating and air-conditioning schedules

Thanks to the Desigo Insight BEMS we have monitored the heating and ventilation systems for over a week between 18 and 24/02/2015, i.e. in winter. Figure 3 shows the example of a staff office in the CPS Department in the northern side of CLE (thus without solar irradiance). The main y-axis corresponds to how much the valve serving that office is opened (0-100%) while the secondary y-axis corresponds to the temperatures measured (in the office, outside the building and the HVAC set point of 22C). At a first glance, this figure shows that the heating system works constantly during day and night; indeed, it works harder at night than during the day, because of the high peak in the external temperature (notice that 21-22/02 were a weekend).

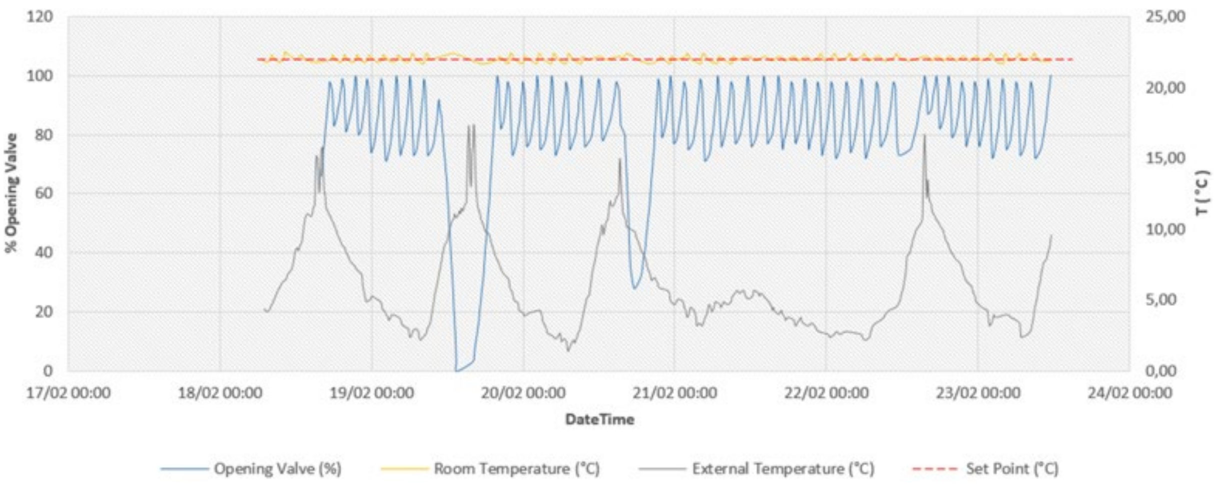


Figure 3. HVAC system at Campus Luigi Einaudi: staff office monitoring in winter. The plot shows the set point (red line) of 22C, the opening of the heating valve (blue line), the temperature in the office (yellow line) and outdoors (gray line).

The ratio of the total area below the blue line (the % opening valve) during nights and weekend and the area for the whole week is 0.73, which gives an indication of how little the system is optimized. Of course, one needs to keep heating during off-hours but the temperature in the office is stable at 22C during all nights and the weekend.

Second, Figure 4 shows the result for a Computer Classroom, on the ground floor, again in the northern side of the Campus. In this case, the heating set point has been changed on 20/02. In the left side of Fig.6 there are several peaks, all at night. After the target temperature has been lowered to 18°C the valves no longer open. This simple experiment proves that by changing the heating settings, or even better using a simple predictive model based on weather forecasting, one can considerably reduce the consumption, especially during holidays and weekend.

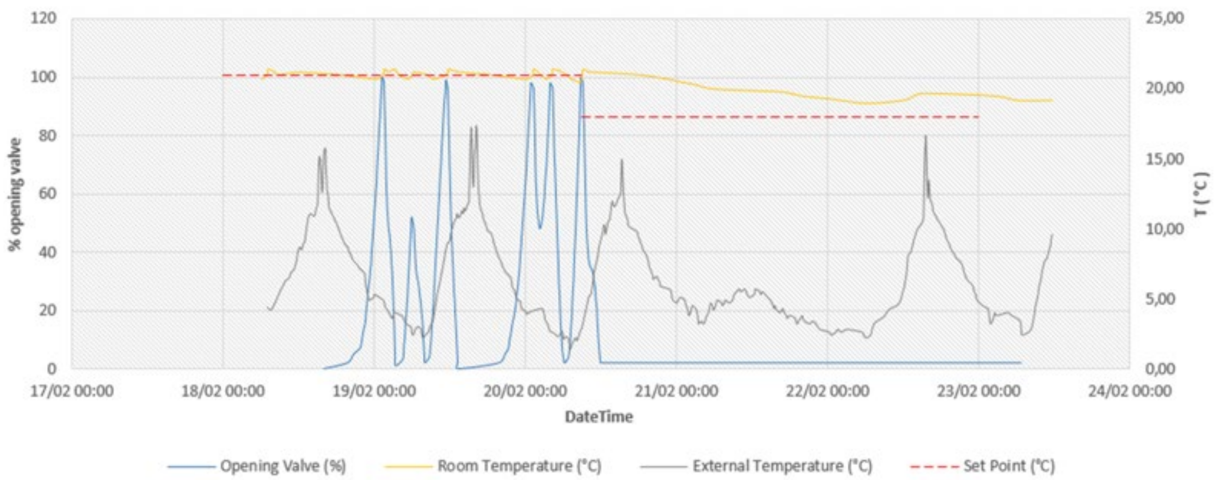


Figure 4. HVAC system monitoring (computer classroom). Changing the set point and exploiting weather conditions a remarkable energy saving can be obtained.

2.3.2_Off-Hours Lightings

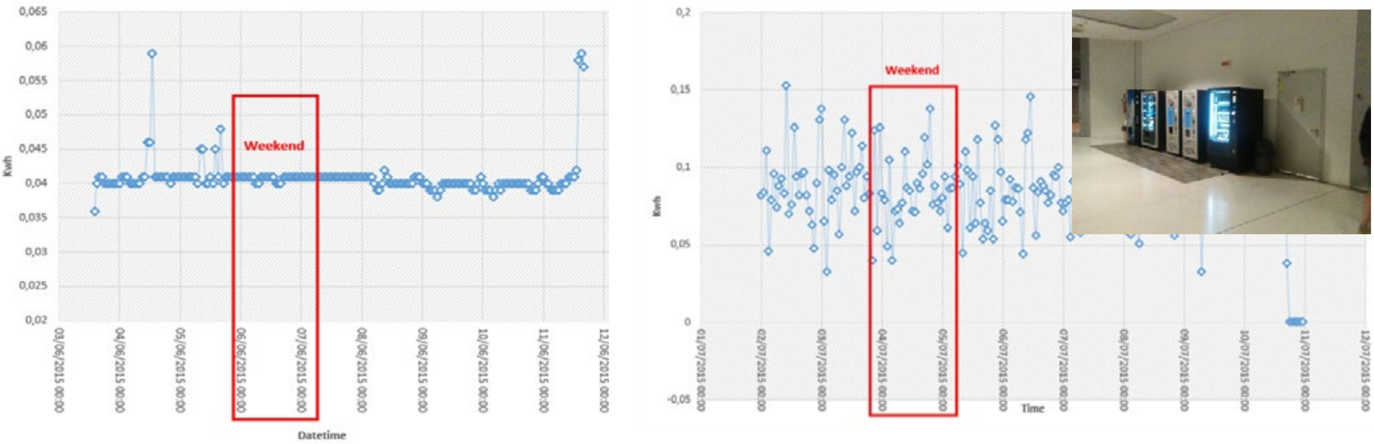
In this subsection, we consider another example of wrong scheduling, concerning off-hours lightings. Figure 5, on the left, shows the schedule for the garage lightings, while on the right side it shows the external lights, which remained on the whole night, shining on a ping-pong table, even if the entire Campus was closed. In fact, all the external lights were constantly on, from 17:00 until 8:00AM, as well as the garage lights and the security ones, on all floors for the whole night.

It is easy to compute the possible annual saving one can get from a more careful use of external, garage and internal security illumination: respectively 31600kWh, 26100kWh and 80000kWh, which is equivalent to a total saving of 25000 € and a CO_2 emission reduction of 54.5 tCO_2.

Figure 5. Top: wrong lighting schedule for garage lighting. Bottom: photo from a night inspection.

2.3.3_Generic Electric Loads

Two different targeted electrical audits have been performed during a one week period. The data have been taken with the CT sensor Efergy 2.0 Classics. Figure 6, on the left, points out the power absorption of two PCs in a computer room of building D4. Each PC uses about 20W in standby and 30W when it is working. The waste during nights and weekends is evident. They have been used for only 4-5 hours, for a total consumption of 0.233 kWh, over the 195 hours of the test. In other words, for 191 hours they remained in standby: during only one week the two PC wasted about 8 kWh, which corresponds to the 97% of the total consumption during the monitoring. In general, considering the closing time of the Campus, the 8 hours during the night, the weekend and the holidays during a whole year, about 40 MWh could be saved, for the 369 PCs of the classrooms, which corresponds to a cost saving of 7500€ and a CO_2 emission saving of 15 tCO_2. In addition, there are PCs and various electronic appliances in the staff and administration offices.



A vending coffee machine has been similarly monitored. Figure 6, on the right, points out the energy waste during the nights and the weekends. The average power absorbed by a single vending machine corresponds to about 90W. Considering the 26 vending machines in the Campus, during the whole year, 12400 kWh can be saved, which corresponds to 2300 € and 4,9 tCO_2 of avoided emissions.

Figure 6. On the left: power monitoring for 2 pc within a computer room during an entire week. On the right: a photo from a night inspection and power monitoring for a vending machine during an entire week.

3_Large Scale Web Application

We have also started developing tools for real time monitoring, in order to support the energy and the logistics management of Unito's large building stocks. In the last year we have worked on an open-source online web tool prototype for smart data visualization and preliminary analysis. An Open Source library, HighCharts, has been used as starting point. Other open source tools can also be used, such as D3.js (Bostock et al, 2011), GoogleCharts, bokeh, Julia. (Bezanson et al, 2014). These web tools can be used together to PHP, MySQL

and HTML to create interactive smart data visualization for any type of dataset with direct query to database, or from a real time stream of data.
For the moment, only the consumption data for the period 2010-2014 have been analysed for all buildings in Unito and used as a starting database. In the next subsections, we will describe some of the tools we have developed and discuss their role in supporting future energy efficiency decisions.

3.1_Online Tools

3.1.1_Buildings/Years Comparison

Figure 7 shows the visualization capabilities of the online analysis tool. The user can quickly visualize the data, comparing the consumptions of a building in different years or the consumption of different buildings, and print the electrical consumptions for any building in stock. Figure 7 displays the electrical consumption in 2010-2014 of Palazzo Campana (Maths Department). In particular, the graph shows increasing consumption at nights and weekends (F2 and F3) with respect to daily consumption (F1) and a total consumption higher in 2014 than in 2010.

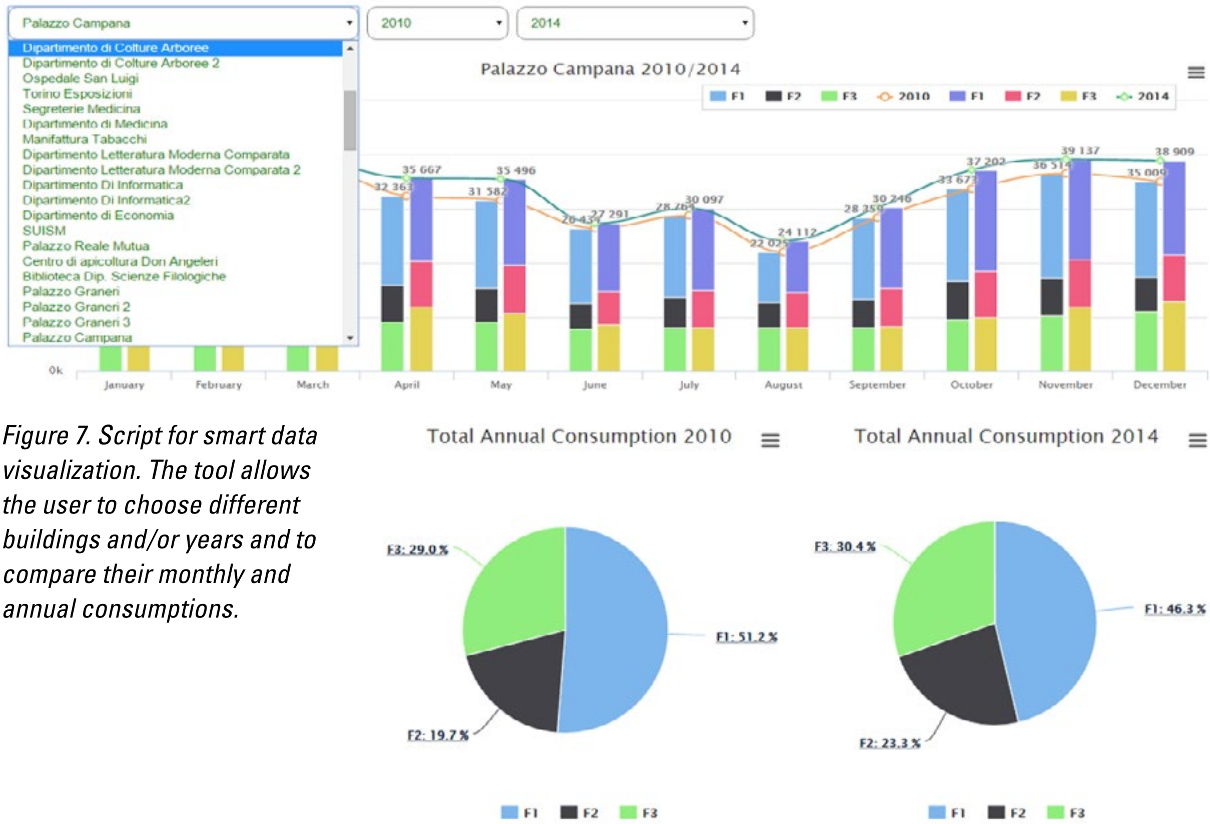
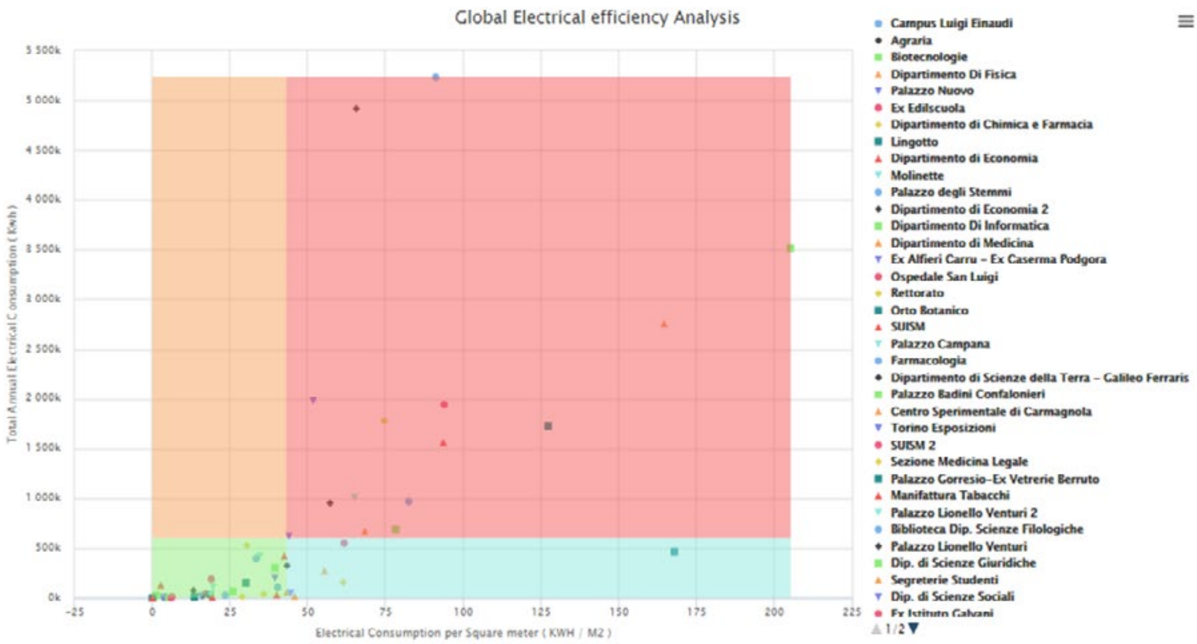


Figure 7. Script for smart data visualization. The tool allows the user to choose different buildings and/or years and to compare their monthly and annual consumptions.

3.1.2_Scatter Method

The Scatter Method is a preliminary analysis method to identify the top priorities for energy auditing in a large building stock (Ariaudo et al, 2011). In Figure 8 the x-axis represents a rough indicator of the efficiency of a building, namely the normalized electric annual consumption per squared meter (kWh/m^2), while the y-axis represents the total consumption during the year. The graph is split into four different quadrants; any quadrant has a different priority. The top right quadrant represents “very high priority” because of high absolute *and* normalized power consumption; thus, maintenance or efficiency renovation could reduce significantly the total consumption of the total stock. The top-left quadrant represents “high priority”: high total but low normalized electrical consumption. In this case efficiency actions are more unlikely to bring a significant improvement; still, even a small improvement would have an impact at the aggregate level. The bottom-left quadrant corresponds to “low priority”, because of the low absolute and normalized electrical consumption. Finally, the bottom-right quadrant corresponds to “medium priority” because of the low absolute and high normalized electrical consumption: efficiency actions, even if necessary, are unlikely to affect the total building stock consumption.

Figure 8. The scatter method allows to quickly identify priorities in efficiency actions. The y-axis represents the total annual electric consumption, while the x-axis represents annual power consumption per squared meter. Each quadrant defines a different action priority for energy efficiency.



3.1.3_Visualization on Interactive Map

A third smart data visualization tool is shown in Figure 9. Thanks to this interactive map prototype it is possible to visualize various types of data collected in the context of the Comfortsense project. This was a living-lab project in the field of the Internet of Thing, focussing on the relation between comfort perception and building management. In this case, the user can choose among objective data, like temperature, humidity, CO_2 concentration, room occupancy, collected by fixed sensors in the building, or some subjective data related to personal feedback on Comfort, thermal comfort, air quality and so on; after choosing a reference interval period, the average during the chosen period is shown directly on an interactive map, with the opportunity to zoom in and out from the entire building to the single classroom. Figure 9 shows an example at CLE. In this case, an overview on people Comfort Feedback is shown. In the Comfortsense project, users could express their global satisfaction within a range from 1 to 5 (1 very uncomfortable, 5 very comfortable). For example 1.75 corresponds to mostly uncomfortable people in the particular classroom shown in the Figure. This kind of visualization allows for a quick analysis of the Comforsense data, and illustrates the importance that the users’ feedback can have in the energy management of large buildings.

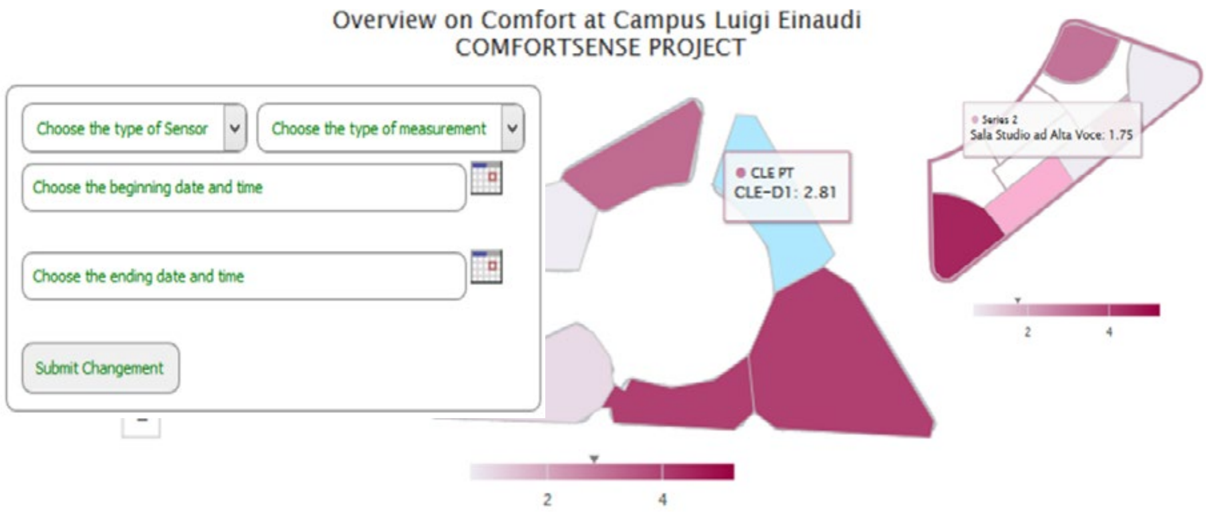


Figure 9. Script for Interactive map. The tool allows to visualize any data collected inside the building and to zoom in and out from the entire building until the single classrooms and offices.

4_Discussion

We have illustrated the first year of work on energy efficiency at Unito by way of a few examples. Some of problems observed are closely related to the reality of a large italian University and the way it has traditionally been managed, with minimal or intermittent attention to the responsible use of energy. While this aspect might be interesting in its own, because it is most likely shared by most italian University and public Organizations, we have tried to emphasize the methods we have employed, which may have wider relevance. We have identified a few general problems: inhomogeneity of datasets, absence of monitoring equipment in historical buildings, lack of tools for data visualization and analysis, and inadequate awareness for sustainability issues. Our approach and the tools we have presented may contribute to solve these problems; in fact a large organization, in order to undertake the path to sustainability and, at the same time, to transparency, can easily adopt some of the discussed approaches: online tools and energy audit, Internet of Things solutions, opensource web applications and opendata are the main strategies. In particular, three different fields of action can be identified:

1. **Data Visualization and Energy Saving:** the aim of systematically analysing energy data in a large building stock such as Unito is to create opportunities to increase the energy efficiency. As a first step, data visualization can help the energy manager to identify wastes and malfunctioning, such as excessive night consumption. Indeed, it is widely recognized that improvements in the building management are a very effective and cheap way to improve the energy efficiency (Holmes, 2007, Goodwin et al, 2013).
2. **User Awareness and Behavioural Change:** the easy availability of energy data enhances the final user's awareness, encourages behavioural change and stimulates final users to adopt a sustainable conduct, such as turning off lights, PCs or heating (Owen et al, 2010, Friedrich et al, 2010).
3. **Scalability of Open Source Software and Hardware:** an open source management system, including software analysis tools, web visualization applications, and a monitoring system can be very powerful and allows for great scalability. It can be generalized and adopted by Public Administrations, by other Universities or schools (Abiona et al, 2009, Lovelace et al, 2015).

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SUSTAINABILITY MANAGEMENT IN UNIVERSITY CAMPUSES: THE ROAD FROM SCATTERED GOOD PRACTICES TO SYSTEMIC TRANSFORMATIONS

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public engagement

Abstract

This paper aims to contribute to the emerging dialogue about how to accelerate the progress towards an institutionalised commitment to campus environmental sustainability. It will analyse two cases of good practices made to date in the field of "green universities" management, looking into two experiences, interviewing their main stakeholders and revealing the main sustainability activators and barriers to transfer and widespread similar institutional transformation. A range of data is presented, from reports and interviews about lessons learned and approaches emerging from different environmental strategies to quantitative indicators analysis from the green metric reporters. One Italian (Politecnico di Torino) and one Mexican university (Universidad Autonoma de Tamaulipas) are taken as success cases for different sustainability perspective. The subject matter is wide ranging as it is intended as a starting point for the reader to pick and choose ideas that may warrant further investigation in their own university context. Even though many of the ideas presented need further exploration and development, in their current state they may prove of some value to the reader as a catalyst for a different level of sustainability in higher education institutions.

1_Introduction

Half of the world's inhabitants now live in cities. In the next twenty years, the number of urban dwellers will swell to an estimated five billion people. NIMBY (Not In My Backyard) and BANANA (Build Absolutely Nothing, Anywhere, Near Anybody) city users' motto (Wester-Herber, 2004) seem to be very far from the KEFA - (Knowledge Everywhere For Anybody) and B-GOT (Beyond GDP, Beyond Oil, Beyond Tangibles) goals of European policies and enlightened researchers (Arrow et al., 1995). Plus, cities still consume enormous quantities of fossil fuels and emit high levels of greenhouse gases, but our planet is rapidly running out of the carbon-based fuels that have powered urban growth for centuries, and the eco-efficiency approach found in previous European policies seem to have failed in make us curb our greenhouse gas emissions (Chapman, 2012). What we surely know is that the city is the playground for tackling this issue. The requested change must come from the cities, with its citizens and its planners, as privileged sites of knowledge production and innovation, as well as strategic management hot spots. In this work, university campuses are identified as privileged sites in the city to observe, in a delimitated border, which resilience activators, community responses and flexible governance dynamics could take place for energy reduction (Evans, Jones, Karvonen, Millard, & Wendler, 2015).

There has been tremendous growth in the sustainability movement in higher education over the past 15 years. This growth has shown the need for stronger methods to measure progress toward achieving the sustainability that many claim. The Association for the Advancement of Sustainability in Higher Education or "AASHE" has a standard method for monitoring the sustainable progress for universities mainly from the United States and Canada. Launched in 2009, STARS is a transparent self-reporting tool and analysis

available to universities. The system works by measuring the sustainable performance in academia, operations and administration using default settings. Since STARS was launched in 2009 have been more than 300 institutions evaluated by 2014 and more than 400 participants in 8 countries, the updated STARS 2.0 version allows institutions outside the United States and Canada participate and be evaluated from 2014 (Lidstone, Wright, & Sherren, 2015). The world University Ranking Green Metric was established in April 2010 in order to provide a profile that could be used to compare the commitment of universities to a greener future and to promote their sustainable operation. The Ranking expects to promote awareness of the institutions of higher education and the value of policies and systems that will have a positive impact on global warming and climate change, particularly those that help reduce carbon emissions promote energy efficiency, alternative forms of transport, campus reforestation and waste recycling. Therefore, campus sustainability has become an issue of global concern for university policymakers and urban planners, as result of the living lab model that bring at cluster scale the impacts of campuses activities and operations. The issue has also been intensified by the pressure from government environmental protection agencies, sustainability movements, university stakeholders as well as the momentum of other forces including student activism and NGOs (Caeiro, Leal Filho, Jabbour, & Azeiteiro, 2013).
A sustainable university is defined by Velazquez (Velazquez, Munguia, Platt, & Taddei, 2006) as ''a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimisation of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfil its functions of teaching, research, outreach and partnership, and stewardship in ways to help society make the transition to sustainable lifestyles.'' Cole (Cole, 2003) also defines a sustainable campus community as ''the one that acts upon its local and global responsibilities to protect and enhance the health and well being of humans and ecosystems. It actively engages the knowledge of the university community to address the ecological and social challenges that we face now and in the future”. A sustainable university campus also connotes a clean and enjoyable campus environment that promotes equity and social justice having a prosperous economy through energy and resource conservation, waste reduction and efficient environmental management that benefits the present and future university community.

There is a common understanding in the literature that a sustainable university campus implies a better balance between economic, social and environmental goals in policy formulation as well as a long-term perspective about the consequences of today's campus activities. As sustainability is characterised by economic growth based on social justness and efficiency in the use of natural resources, it should includes the recognition that all stake holders' co-operation and participation is required to effectively achieve sustainability goals. However, as Lang (Lang, 2015) warns, there are very limited correlations between institutional environmental performance and adoption of campus sustainability initiatives, be they targeted operational or coordination and planning best practices, or curricular, co-curricular or research activities. Conversely, there are strong correlations between environmental performance and campus characteristics, namely, institution type and climate zone. The traditional practices and regulations of addressing environmental issues, project and ad hoc manner have become highly inefficient and cannot guarantee sustainability. Environmental issues are becoming more complex, multidimensional and interconnected and environmental sustainability by its very nature requires an integrated and systematic approach to decisions making, investments and management (Disterheft, Caeiro, Azeiteiro, & Filho, 2014) but also as a benefit to the overall paradigm change towards sustainable development and contribute towards the integration of sustainability concept into the university culture. So far, there have been comparatively few research studies on participation within sustainability implementation at university level, and a more differentiated understanding of these processes is still missing, both in the practice of conducting a participatory process and in the sustainability assessment. This paper addresses some of the failures and successes experienced within participatory approaches in campus sustainability initiatives, and deduces a set of critical success factors and emergent clusters that can help to integrate the dimensions of participation more inclusively into sustainability assessment. Following a qualitative approach and inspired by the Delphi-method, semi-structured expert interviews (N\u00a0=\u00a015. Therefore, there is need for a professional and systematic environmental management approach to reducing the consumption of resources and negative impacts of the various campus operations and promoting campus sustainability. Unfortunately, this approach is generally lacking in most universities, and achieving sustainability is not easy (Alshuwaikhat & Abubakar, 2008).

2_Methodology

The present study tries to understand the effects of some management practices in building a sustainable community within the university, by setting a fertile ground for long-term sustainability practice roots. After having explained why the sustainability concept is being embedded in today's higher education institutions, the literature shows the limits of the current scattered and spontaneous approach toward sustainability management. Then, two case studies are taken to demonstrate very different ways to achieve sustainable communities, although not included in standard key performance indicator of sustainability.

Data from the Politecnico di Torino, in Italy (par. 3), the Universidad Autonoma de Tamaulipas, in Mexico (par. 4) have been collected from the living lab via one-to-one interviews with local officers, surveys, field-work qualitative documentations and on-line websites. Ex ante and ex post energy trends after sustainability actions have been tested though historical data set of energy consumption both from smart meter data log and from bills. A relevant source of information to complement the interviews came from public and private documents (annual reports, websites, activity reports, campus assessments, internal mail, PowerPoint presentations, news media articles and the Archibus data-base). Most of these documents were obtained on the Internet, although the interviewees provided some reports and memos, too. In the conclusions, some policy suggestions for the scalability and transferability of the good practices are outlined toward a systemic transformation of the sustainability management in contemporary universities.

3_The Politecnico di Torino and the IT support in sustainability management

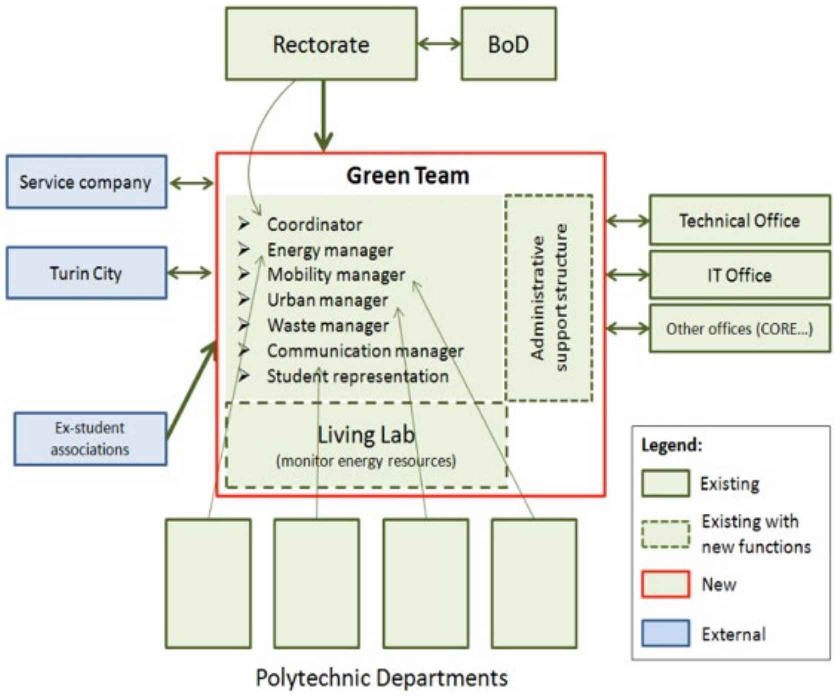
The Politecnico di Torino (POLITO) is organised on a rather wide arrangement in distinct geographical locations with very different features from the architectural, urban and functional points of view. In 2012, the Polytechnic accounted for 32000 students in 60 courses (undergraduate and postgraduate), more than 30 masters and 24 PhDs; 18 departments; 20700 m^2 of classrooms; 850000 m^2 for researchactivity; 1600 employees, including 800 teachers. The status quo sees the Politecnico in a very low position according to the national and international Green Metric Ranging, although: the 100% of the electric energy consumed in the campus comes from renewables, and a consistent part of the thermal energy comes from district heating; a new PV plant of 400 kWp has recently been approved, new double-framed and low-e windows substituted all the old windows, thermal insulation has been provided for all the most dissipative walls of the main building; Car-ride, car-pooling, electric vehicles charge stations, public transport reduced seasonal tickets and closed bike parking are some of the mobility manager recent achievements; 0-km food, green product procurement, paper-less communications, campus differentiated waste collection points, water dispensers are other tangible and visible effort in the direction of sustainability education, as well as the introduction of night open lectures, sustainability-dedicated courses and several international project on campus sustainability management. In the 2014 Green Metric Report, POLITO's total ranking was 4103 vs. 6094 (University of Bologna, ranked first in Italy) e 6057 (University of Turin, ranked second). The 2000 points that put away POLITO form the top have been lost mainly in the Waste and Transportation categories. Nevertheless, in the Energy and Environment category POLITO ranked well among the others thanks to the monitoring system and the IT large use in the Living Lab.

3.1_IT solutions for sustainability management

In 2012, the Living Lab began a fruitful collaboration with departments and faculties on various research projects and teaching initiatives with a focus on energy and sustainability, allowing to share common infrastructure acquisitions, technological resources, expertise and, most important, dataset. The Smart and Green Building Services Management provided by the Living Lab is the result of the close cooperation between different entities and divisions (energy manager office, energy department, Information Technology Area, Construction and Logistics). In the Living Lab, all data streams are collected from on-site sensors and then processed and analysed. The main aim is to provide a decision support for the energy management, but there are also regular requests for research support and various educational initiatives.

In 2015, the Politecnico di Torino, in collaboration with the Higher Institute on Territorial Systems for Innovation (SiTI), has being carrying out a project, namely "Sustainable Path", aiming at tracking down all the sustainability initiatives. The first outcome is a report compiled for the ISCN – International Sustainable Campus Network - that serves as a basis for the strategic plan further directions.
In the light of what emerged along the scouting of the different, hidden but yet virtuous sustainability actions in the energy, waste, mobility, communication and urban management fields, the report eventually proposes to set a long-term group work, a green team, which will be in charge of the overall sustainability strategy of the Athenaeum. Current internal managers of the aforementioned fields could make up the core, and be supported by the existing Living Lab. The idea is that this precious structure will be used and supported by a sustainability coordinator, in charge of in-out communication with the dean's office and the board of directors, and flanked by an administrative office for estate and infrastructures maintenance, logistic, external communications and every initiative falling into the POLITO sustainability framework. The so composed Green Team will interrelate with the National and International network of sustainable campuses, alumni, students, general public, city council and interested companies and start-ups.

Figere 1. The sustainability management scheme at the Politecnico di Torino. Source: author's data elaboration from internal documents preparation for the ISCN sustainability report.



The main points of interest that stand out from this diagram are the following:

- The Green Team is made up of members from within the department but reunited with a proper budget just for sustainability action planning, where positions have already been established/formalised; a coordinator has to be named to work close to the Rector and with the internal offices, with the role of acquisition, or new figures might be defined in the future according to actual needs

- The Green Team will collaborate with external corporations (services providers, city councils, private sponsors, etc.) leveraging on the data from Living Lab, which also acts as a centre for the monitoring and collection of data compliant with the mission.

4_The Universidad Autónoma de Tamaulipas and the 'social factor'

The Universidad Autónoma de Tamaulipas (UAT) is located in the state of Tamaulipas, an area of Mexico with warm semi-humid climate, which reaches high temperatures in summer. It is an institution with degree studies ranging from high school to doctorate. It has approximately 41,000 students and about 7,300 employees, has a length of 40 years and is the largest in the region. It's commitment with sustainability started in 2014 with the integration of its own sustainability committee and their participation with GREENMETRIC as well as AASHE. As a result of this university keen in sustainability evaluations it has obtained a place in 2014 GREENMETRICS Ranking and a bronze medal during 2015 from AASHE STARS.

The General Coordination of Sustainability emerges as cross-office inside the research department. It is responsible for coordinating the efforts of sustainability, generate strategies for the institution accreditation as well as projects to communicate and disseminate the results to the university community and society. The start of its sustainability effort was on July 2014 with the creation of the sustainability development committee. This committee responsible for the creation of a sustainable development plan, sustainability evaluations of the institution and any project related with sustainability in order to lead the University through a sustainable path. It is also in charge of assessing the president to identify and prioritize institutional efforts. It is officially integrated by: an institutional president; secretaries for Linking and extension, Research, Management, Academic, Finances; General Institutional Lawyer; Institutional Controller; Internal Assessor; Executive Secretary.
Any sustainability-related project has to be approved by the committee. The executive Secretary has its own office the Sustainability Coordination, in charge of the sustainability report and all the projects proposed to the committee.

4.1_Best Social Practices at UAT

According to STARS, the two main impact sections for social factor are the Campus engagement and Public engagement criteria. It is very important to notice that the credits with higher social impact are those with higher points achieved for UAT besides the Academics. Both of these groups of credits represent the 30% of all available points in STARS, the same points available for their highest category. However, those are the less considered, as being naturally part of the institution branding activity. One of the reasons for this, is that the University has since always a great keen on student and staff well-being, and part of all developing plans always includes the students, the staff and the community.

In order to analyse STARS social impact credits relationships an interaction mapping has been done. With this map it is possible to observe the main credit categories related to the social impact. As it is possible to observe Campus Engagement category has a relationship with all the other categories in the system. Therefore, the impact of the social factor in the campus sustainability is evident. Even though Campus Engagement and Public Engagement categories are directly working with social impact, they are related with the other categories such as investment, health, wellbeing and work, diversity and affordability, coordination, planning and governance among others.

One of the most important things to reflect on is that all strategies and programs analysed for the STARS ranking were already applied, designed and put in place well before a sustainability plan even existed. For an institution where sustainability has not been even mentioned in the strategic plan but actually been practiced throughout its recent years, a BRONZE medal by the STARS committee is a very important signal. It means that probably not all the efforts made in the management rooms are necessary or assure the good result in terms of user awareness and mentality shift, while leveraging on "physiological" and usual environmental behaviours just "celebrate" the activities realised by the staff, faculty and students by their own initiative.

For the "Outreach materials and publications" credit, UAT gained score thanks to a radio broadcast called "Universidad Sustentable" (Sustainable University) transmitted by the University Radio Station "Radio UAT". The program includes invited researchers, faculty members or staff friendly communicating all sustainable issues in our University, city, state, country and all around the world. In the "Community Partnership" credit two exemplary practices got the score. The first one is called "COMASS" (Operational Center of Multidisciplinary Attention and Social Services), and it is a center created in 2004 with the purpose to link students to vulnerable communities. Intended to impact the community in the short, medium and long term through free delegations by public institutions, it provides free services regarding health, nursing, social work, law, informatics and statistics to the community. By 2014 it has served 6 neighbourhoods and has benefited 12522 people. Another community partnership program is the "Laying Hens Program". It consists in the distribution of laying hens to families in rural communities for self-consumption and for trade. It takes place annually, but it has the constant participation of students, which are in charge of monitoring the growth process of the hens during the first weeks of the project. It is designed for families in rural area in order to get them additional income, providing better nutrition to their families and encourage roots in their communities. It is carried on in collaboration with the city council and the veterinary school. About ten thousands laying hens are distributed annually; during the first year, the 94% of the survived birds produced between 60 and 70 eggs per week. This managed to revive the economy in this sector. The "Community Service" credit acquisition in Mexico is very different compared to other universities. Since community service is an indispensable requirement to obtain a professional degree, every student must contribute in no less than 6 months and no more than 2 years with 480 hours of community service. The result is a contribution of 4,926,720 hours in a year thank to the participation of 25,072 students.

The “Wellness Program” credit is another exemplary performance for UAT. All enrolled students have an insurance that covers health problems related with University activities. This insurance covers preventive courses in birth control, stress control, weight control, diabetes, cholesterol prevention, and many others. All the Union members of the university benefits of an annual salary increase, attend free courses and workshops in order to increase their salary or their working category, receive a 100% scholarship for their children studying at UAT, apart from free medical devices such as needed glasses, orthopaedic appliances, hearing, prosthesis, etc. Lastly, the “Affordability and Access” credit has being achieved as a result of the low cost of studying in Mexico. Being UAT a public institution, the average cost per semester is about $220 USD for any careers offered by the University. Low-income students could apply to scholarships covering the study cost as well as personal needs.

5_Discussion and Conclusions

The Politecnico di Torino adopted a centralised policy that leverages all the energy consumption upon a fine data monitoring system and centralised decisions. Its relatively low position in the UI Green Metrics world university ranking does not reflect a quite virtuous energy consumption and resources management, both compared to similar institutions and to its previous years’ performance.

Conversely, the Universidad Autonoma de Tamaulipas does not collect any quantitative information regarding energy/water consumption. However, to comply with the Green Metrics report it had to scout all best practices related to sustainability via on-site surveys, interviews and the dissemination effort of the entire sustainability office. The result has been a university Most of the sustainable good practices have been carried on without any emphasis or community branding; yet, UAT’s high position in international ranking demonstrates how important can be qualitative data collection and analysis even outside specific indicators accomplishment.

Perhaps most importantly, a common weakness within the two cases is the absence of a long-term follow-up of the promoted activities. All projects tend to be carried out over the short term (six months to a year) but no indicator to measure the efficacy of building renovation initiatives, sustainable farming educational activities or public lectures affluence is registered. This may not be sufficient to adequately evaluate the persistence of the energy savings benefits, social impacts or environmental education results, if the goal is to assure long-term changes in consumer behaviour and practices. It also makes difficult to assess the actual size of the direct rebound effect with a high level of confidence. Therefore, a general need is to call for appropriate indicators and mandatory track for sustainability initiatives inside each university.

Moreover, a rich web-platform could be the place where opportunities and problems will become visible and proposals will be collected and shared. Of course, the prerequisite for the success of the initiative is the creation of a strong awareness on the topic of sustainability within the community, something that at present state is still missing. The governance of the process is fundamental for supporting and feeding a complex and long-term project like the one we are proposing, and to manage a large amount of ideas and proposals by the community.

Eventually, above all in the energy efficiency and renewable energies field, there is no % of energy to be saved in one year, from now to 2020 (reduction of fuel consumption and dispersion), or % of saved money by widespread use of renewable sources, or %reduction of waste water management, and so on). Aiming at no specific target leads to vague researches and monitoring activities with no useful outcome nor action to be suggested, and no specific request of more equipment by the living lab to become more competitive, as well as a consequent lack of results in terms of money saving and image improvement.

As good scalable example, the UAT "sustainability office" could be the solution to take care and supervise first of all four main themes or areas of interest, namely "People, Energy, Environment and Social Impact", deliberately broad in order to encourage an interdisciplinary approach.

A crucial factor to drive policies and funding schemes is certainly the adoption of a common framework to make the economic board of university dialogue with the environmental and social activist and managers. To assist in longer term strategic planning, a set of sustainability metrics has to be developed covering the full range of the university's operations. This is indeed the main barrier highlighted in the study of Lidstone (Lidstone et al., 2015) regarding facilities management directors' conceptualizations of sustainability in higher education. Since the financial barrier was the most often reported when asked what the major hurdles are to achieving institutional sustainability, and many participants also reported they do not expect this barrier to disappear in the future, much work has to be done in order to enlarge the conceptualizations of sustainable development mostly focused on environmental sustainability, specifically energy, resource management, and waste reduction. This is consistent with the findings of (Wright, 2010), where university presidents and vice-presidents also favoured the environment over social and economic factors when discussing sustainability. These thoughts are echoed by the respondents' ideas of a sustainable university, with environmental sustainability being the most popular response. This focus on the physical impacts relating to sustainability is not surprising, as the facilities management stakeholders largely deal with the physical aspects of the campus, and have the most control over the environmental factors of the institution.

An holistic metrics for social and economic assessment of environmental management practice will allow financial boards to track performance over time and make comparisons with peer institutions where comparable data are available (Sonetti, Lombardi, & Chelleri, 2016). Metrics consistent with the proposals for a new annual sustainability assurance report have to be further developed.

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Assessment Methods and Tools

ENVIRONMENTAL ASSESSMENT METHOD FOR DECARBONISED URBAN RENEWAL

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Abstract

Realising urban transformation towards sustainability and low carbon future can be easily pursued in new cities and new urban development, nonetheless the historical and established high density cities and the ancient built environment will require a substantial different types of intervention, in order to achieve reductions in GHG, to mitigate UHI effects and, consequently, to provide outdoor comfort for people.

Amidst different strategies to overcome barriers to decarbonising cities, an effective strategy can be played by bioclimatic design and passive systems to be applied for spaces between buildings and at a precinct scale for creating low carbon, resilient cities.

Structural elements, finishing materials and green design play a significant role in improving outdoor comfort for people and in reducing urban environment carbon footprint as a whole in historical settlements.

The paper addresses the needs to analyse and intervene in historic districts renewal and in other consolidated public spaces, whose requirements represent one of the greatest sustainability challenge today, in order to overcome the lack of appropriate assessment tools with which to accomplish that assignment. This paper provides a qualitative and quantitative assessment method to improve sustainability in public spaces, in order also to enhance outdoor comfort, by outlining a designing approach for rehabilitation of urban built areas. Authors aim at providing a scientific method that integrates the needs of preservation of urban public spaces thanks to climate sensitive urban design, through bioclimatic design techniques and passive solutions, with support of those will enhance urban retrofitting strategies, focusing on human comfort.

1_The drive towards a low carbon awareness in urban area

Covering just 3% of Earth's surface but housing more than half of its population, cities account for 70% of global energy demands.

An increase in significant city-wide actions across all action areas demonstrates that cities are learning from their own experiences, as well as those of other cities which actions to implement, how to implement them, and where to allocate capital resources to convey the greatest benefits.

One of the most crucial issue to address is to analyse and intervene in historic districts renewal and in other consolidated public spaces, whose requirements represent one of the greatest sustainability challenge today, in order to overcome the lack of appropriate assessment tools with which to accomplish that assignment. Taking climate action is also fuelling the expanding green economy, creating new jobs, developing skills, and bringing economic advantages for city residents across the world. This is why cities can play a crucial role in ensuring a climate safe and a low carbon future.

Cities have proven themselves fervent and capable in their approaches to tackling climate change and delivering local action that contributes to national and global climate targets, both in case of new neighbourhood development and in case of urban renewal.

In that sense Climate Sensitive Urban Design CSUD aims at providing a healthy, comfortable urban environment that meets the dwellers' requirements,

making buildings and open spaces climate-change resilient, ensuring an efficient use of energy and resources, to get to a complete life cycle assessment for buildings materials and components selection, thanks to passive and bioclimatic architecture principles.
These targets mean low carbon design, energy footprint awareness, carbon footprint and environmental labels for every kind of measures and initiative taken to reduce the severity of climate change or their exposure to the effects of climatic alteration inside the cities.

1.1_City renewal overview and open issues

Although questions remain about how exactly GHG emissions should be attributed geographically, most of the world's GHG emissions are ultimately attributable to cities, which are centres of economic activity.
Cities are responsible for two-thirds of global energy consumption, and this proportion is expected to grow further (IEA 2008). Although cities' ambition to scale up decarbonising measurements is reflected in their increasing allocation of staff-time and monetary resources to build efficiency in responding climate challenges, even a Climate Sensitive Urban Redesign could be extremely successful and money saving though. Climate Sensitive Urban Design is an integrative act, that depends on an extensive understanding of environmental issues, possibilities and consequences of developing different possible scenarios.
Implementing resource efficiency and climate sensitivity in existing urban environment requires a factual integration of highly complex urban conditions. Planning processes for resource-efficient and climate- sensitive neighbourhood or urban design leads to a process of decarbonizing neighbourhoods and cities.
Amidst different strategies to overcome barriers to decarbonising cities, an effective strategy can be played by bioclimatic design and passive systems to be applied for spaces between buildings and at a precinct scale, with the intention of creating low carbon, resilient cities. Structural elements, finishing materials and green design play a significant role in improving outdoor comfort for people and in reducing urban environment carbon footprint as a whole in historical settlements.
A climate sensitive approach should consider the city itself as a decarbonizing lever. In that sense, a proper passive and bioclimatic design, along with specific revamping or retrofit actions for open spaces, offer a special opportunity to achieve the goal of a sustainable and low carbon city. The most challenging aspect is that the growing attention to the energy saving issues has thus crossed the traditional boundaries that just considers the building envelope, shifting the focus towards the definitions of some specific parameters and index to be translated to the scale of the urban space, public ones and transition places.
The increasing attention to the quality of the building environment and the comfort of architectural spaces has led to the adaption of some of the existing evaluation procedure in order to assess the overall outdoor conditions for users. One of the starting points is to consider that the city itself could be able to create a general condition of comfort and well being and, consequently,

leads towards a reduction of GHGs emissions, thanks to many factors. The city itself is actually a dynamic resource for the enhancement and mitigation of daylight performance, temperature-humidity conditions, noise and air quality, since the city itself contains most of the elements that can generate and mitigate the climatic and microclimatic conditions.

This means that, going beyond mitigation, each urban environment, highly or lowly density built up, can adapt itself to the effects of climate chance, by scaling up different scale solutions. This paper aims at demonstration that a low carbon and climate-based approach can be very effective in reaching these targets.

Merging together qualitative and quantitative assessment methods can evidently improve sustainability in public spaces, in order also to enhance outdoor comfort, by outlining a designing approach for rehabilitation of urban built areas. Quantitative assessment passes by wind distribution, in order to evaluate the strongest wind direction, its velocity and wind air temperature. Afterward the sun path related to the specific location has to be assessed to evaluate which day is the most sunlit and which one has the longest day.

1.1.1_Levers and measures

Climate action can range in size and targets from relatively small and targeted initiatives to a large scale and citywide programme. City related initiatives to reduce carbon emissions in order to achieve a low carbon outdoor environment do not have to exhaust municipalities' resources, since city authorities can deliver actions and solutions on a variety of budgets. In moderate climate zones it is actually possible to modify the microclimate with simple strategies such as installing windbreaks and shadings, or at least providing radiation-attenuating devices. Urban forms can also modify the climate of a city and differentiate it from the climate of the surrounding rural areas.

The nature and scale of climate action vary across different sectors. This paper would mainly focus on climate-based, climate sensitive and cost effective measures to be applied on outdoor spaces like squares, public gardens and transition places inside the historical cities, where other measure could otherwise be expensive and too disruptive. Although cities' ambition to scale up decarbonising measurements is reflected in their increasing allocation of staff-time and monetary resources to build efficiency in responding climate challenges, even a Climate Sensitive Urban Redesign could be extremely successful and money saving though.

Several parameters have been demonstrated to be effective in reducing temperature and GHG emission, tackle climate change, by playing on: Topography and elevation; Ground Cover and Vegetation; Wind distribution among buildings and roads; presence of Green Mass; presence of Water bodies; Urban geometry (orientation of the streets and urban form) and Albedo values.

In case of urban renewal, regrettably, there is no inclusive set of guidelines or literature case for moderate climate zones and, even the well-known theories of Givoni (1998) or Emmanuel (2005), do not pay sufficient attention to moderate climate zone.

By contrast, this paper will be focused on Climate Sensitive Urban Design for urban renewal also in order to develop a climate-conscious and energy-efficient design, both at the building and urban scale, by stating a range of key parameters related to passive design and bioclimatic principles that affect the urban microclimate and recommendations for an urban design renewal, which provides outdoor comfort conditions for pedestrians both in summer and winter, reducing energy demands inside buildings, involving green masses, water bodies and finishing materials to control the UHI effect.

2_Vision, principles and key aspects to define a guideline for decarbonized urban renewal

A proper microclimatic assessment can be also used in case of urban renewal, in order to provide useful tips to support architects, designers and to intervene correctly. Even a sun shadow map can play a crucial role in order to point out the overcast areas or sunlit zones, clearly stating where to provide permeable and low albedo values materials, or where to design canopies to protect from overheating situations.
Since 2012 we are trying to assess a valuable design strategies to intervene in case or urban renewal inside the urban dense texture, during multiple university classes; the goal is trying to define a passive and effective qualitative and quantitative approach for resource-efficient and Climate Sensitive Urban Design.

2.1_Qualitative and quantitative assessment

For each assessment step students are asked to identify the most likely dangerous or harmful conditions in order to provide proper solutions: starting from collecting the local weather data, thanks to graphic and geometric evaluation of Urban Form & Building porosity, passing through the investigation of the dose of sunlight penetration in urban canyon, moving to Wind distribution analysis, towards the exploration of urban finishing materials, by appraising albedo values both for horizontal and normal finishing building materials.

Table 1. Assessment phases

Assessment Phase Number	Assessment Target	Objectives and action category
1	Urban form	A: Building porosity and streets geometry
2	Solar radiation	B: Sun light penetration and sun path, shadows map
3	Ventilation	C: Wind distribution
4	Vegetation and albedo	D: Finishing material properties and green canopies E: Water mass and evaporative cooling
5	Mitigation measures	F: Re-performing the general evaluation assessment

All these geometric and simplified data should give also evidence of the presence of green masses, water masses and other urban elements that can affect the urban microclimate.
Analysis of the prevailing wind direction is the further step in order to evaluate mitigation measures to avoid noisy wind or in order to provide natural ventilation where needed.

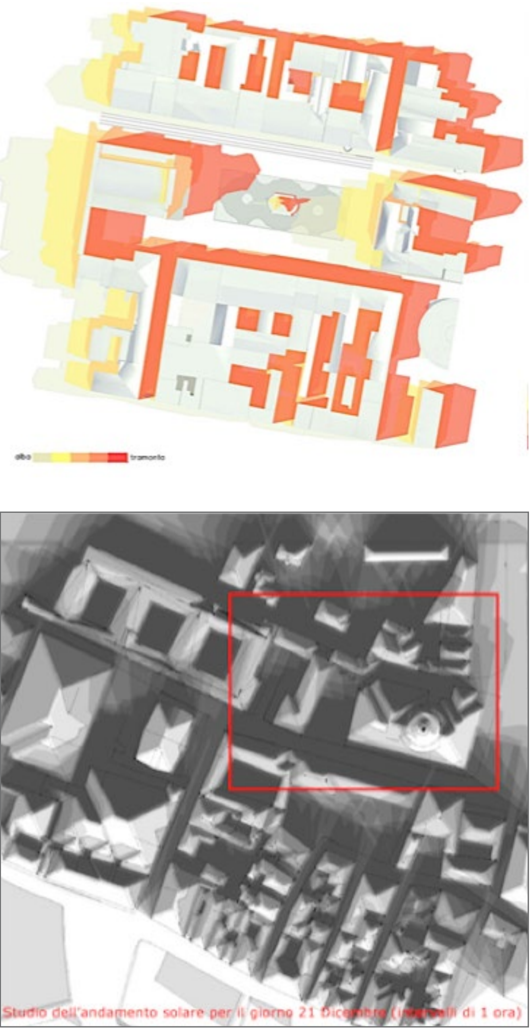


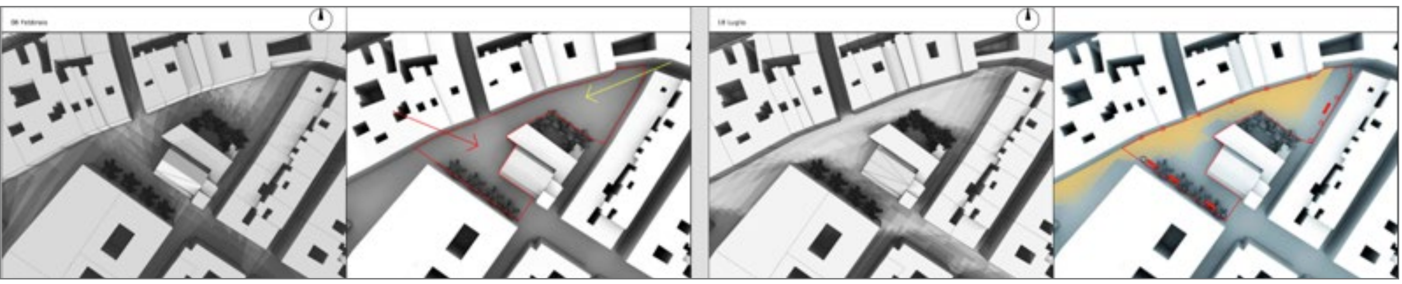
Figure 1. Sun shadows map distribution in La Spezia and in Mantua

Eventually, shadows and sunlight hours distribution as well as related shadows overlapping maps complete the general assessing procedure. In that specific case we usually propose 4 thresholds data to perform calculation: on December 21st, at dawn, at sunset, in two intermediate thresholds (12:00 pm and 15 pm); on June 21st at dawn, at sunset, in two intermediate thresholds (11:00 pm and 16 pm); on the warmest day, at dawn, at sunset and in two intermediate thresholds (11:00 pm and 16 pm); on the coldest day at dawn, at sunset and in two intermediate thresholds (11:00 pm and 16 pm).
In order to provide all these data we suggest using the interactive 3D sun path diagram in Autodesk Revit, Vasari, Ecotect or Google SketchUp, in order to visualize shadows based on the sun's position.
Students are usually asked to resume the most interesting values assessed during the evaluation phase and they are invited to proposing some mitigation actions, corrective measures or any retrofit design solutions to reduce thermal loads and, consequently, CO_2 emissions.
That procedure has been proposed to several master class students and has been performed for moderate climate zone, in numerous northern dense and historical cities in Italy, in dense urban texture in Barcelona, in Paris and in the historic district in Cracow.
For the research purpose, the design of buildings looking towards the evaluated urban portion (walkable streets, squares and transition places) has intentionally been avoided in detailed consideration, because the research focuses on landscaping and outdoor urban environment features, in order to control and achieve a decarbonizing set of measures for the dense city.

2.1.1_Comparing the effectiveness of each measure for different urban environment and microclimatic zones

With regards to the first target "Building porosity and Streets geometry", different assessments carried out during the last 4 years with students' class have demonstrated a low efficacy in reducing carbon emission, considering that modifying the urban street geometry in consolidated urban environment is almost unbearable, both for physical and legislative constraints.
Even tough a rough qualitative assessment of urban porosity can be effective in identifying several measures, valuable for changing horizontal and vertical surfaces materials (albedo value, porosity of materials).
With regards to the second target "Solar Radiation" and its action category "Sun light penetration and sun path, shadows map", many studies demonstrated the significance of these types of evaluation, in order to identify the outdoor areas always lit or under lit, all year round.
Starting from these investigations, is now feasible to provide different types of canopies and awnings to shade over lit areas, to provide protected areas

Figure 2. Sun shadow maps for 4 thresholds, with annotation of over lit and under lit zones and wind distribution, in Piazza della Pomposa, Modena



for summer times, reducing the heat loads and diminishing the UHI effect. Subsequently, students have been asked to suggest different types of shading solutions, like in the images 3 and 4.

Referring to the subsequent target "Ventilation" and related "Wind Distribution", a qualitative and quantitative evaluation can be obtained by juxtaposing the wind distribution map to the assessed urban portion, both considering the wind velocity and the wind temperature, in order to establish when and where the air flow can be positively used to reduce thermal loads, or when it can be used in enhancing outdoor thermal comfort for urban dwellers, according to the Lawson's criteria and other wind charts.

The air circulation is moreover essential in mitigation of extremely high temperatures, due to the ability of the wind to transfer cool air from vegetated or low-density areas in the direction of urban cores, pushing the hot air in the centre upwards.

Furthermore, the criteria "Finishing material properties and Green Canopies" can be carried out using aerial pictures in order to identify the most common albedo values, both for horizontal and vertical finishing materials.

A valuable measure to lower urban temperatures pursued by most authors (Givoni 1998; Emmanuel 2005; Gartland 2008) is therefore changing the albedo value, the surface reflectance of the entire system. This implies that dark -low albedo- surfaces should be replaced by light -high albedo- surfaces whenever possible, so that less solar radiation is absorbed and thus the surface temperatures kept at the minimum.

Although the notion of albedo seems to be overstressed lately, it is widely believed that a higher surface reflectance affects the total energy balance of

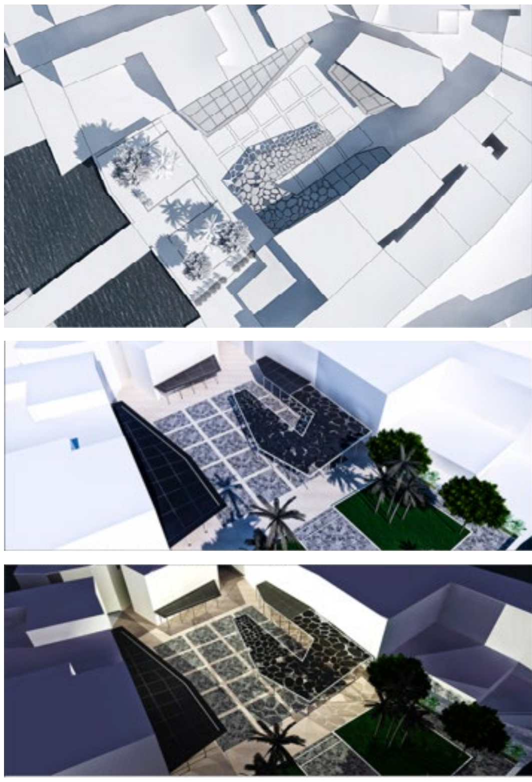


Figure 3. Shadows map for Sirmione, overlooking the Lake Garda and some mitigation measures to avoid overheating effect on the ground, thanks to different types of canopies

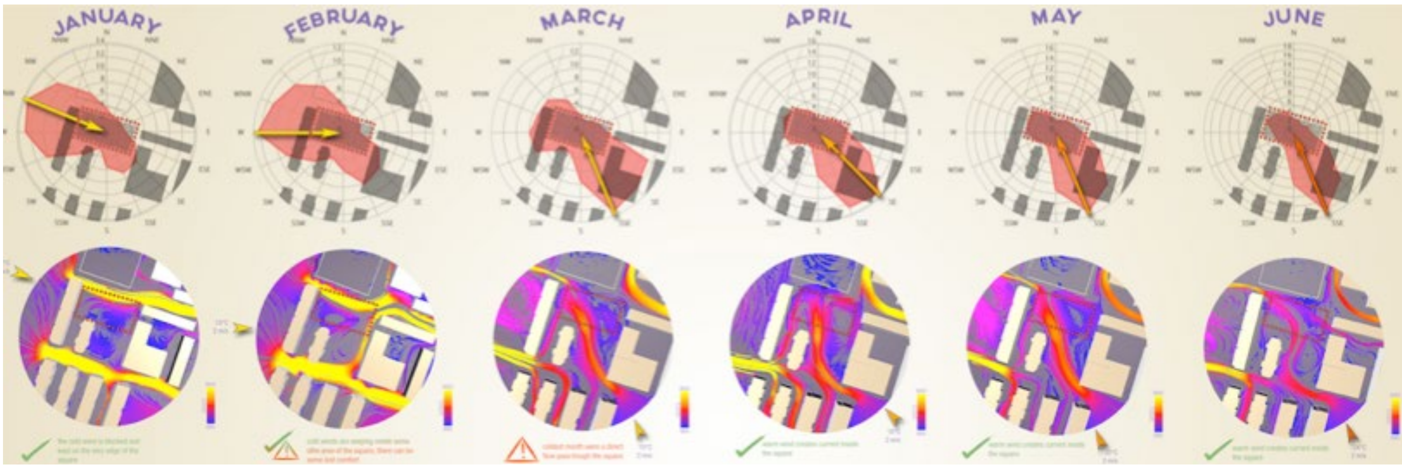


Figure 4. Wind distribution maps in Plaça de José Sánchez Rios, Barcelona

Figure 5. Axonometric view and wind distribution maps and to indicate canyon effects in Plaça de Sant Miguel Barcelona, during summer months

Figure 6. Albedo values overview for vertical and horizontal surfaces in Plaça de José Sánchez Rios, Barcelona

an outdoor urban square, thus lowering the UHI effect, this is why we tried to propose some mitigation measures to control the heat distribution.

The affectivity of the albedo value in densely built-up urban areas is sometimes questionable, also due to the fact that in urban area, a huge part of the reflected rays hits walls of adjacent buildings and thus only a small amount of the solar radiation impacting on walls and streets is reflected upward. Most of the radiation is thus absorbed in the walls of the buildings, regardless of the colour and it is stored as heat and released back into the atmosphere later, causing the UHI effect (Givoni 1998).

Albedo value and cooling effect by vegetation is not only effective in lowering the temperature in the immediacy, but it is also effective in reducing the heat loads on building facades, adding more thermal loads inside the buildings and getting more HAVC, producing, as the final result, a considerable amount of CO_2 emission.

Other effective strategy can be found in the cooling effect of vegetation, in many case much higher in comparison with the effect of reflectance, as many students' studied case have proved, especially in highly density cities.

For the reasons above, green masses should also have a higher priority in designing of surfaces rather than creating light and reflective surfaces, as well as green belt can play the crucial role of wind barrier and urban shelterbelts or evaporative cooling zone, in order to avoid the so called "canyon effect".

3_Conclusions of "research by design"

The research strictly focuses on defining an expeditious method that both involve qualitative evaluations and quantitative design instruments in order to define some corrective measures to be applied in renewal urban areas in order to get a decarbonized urban environment.

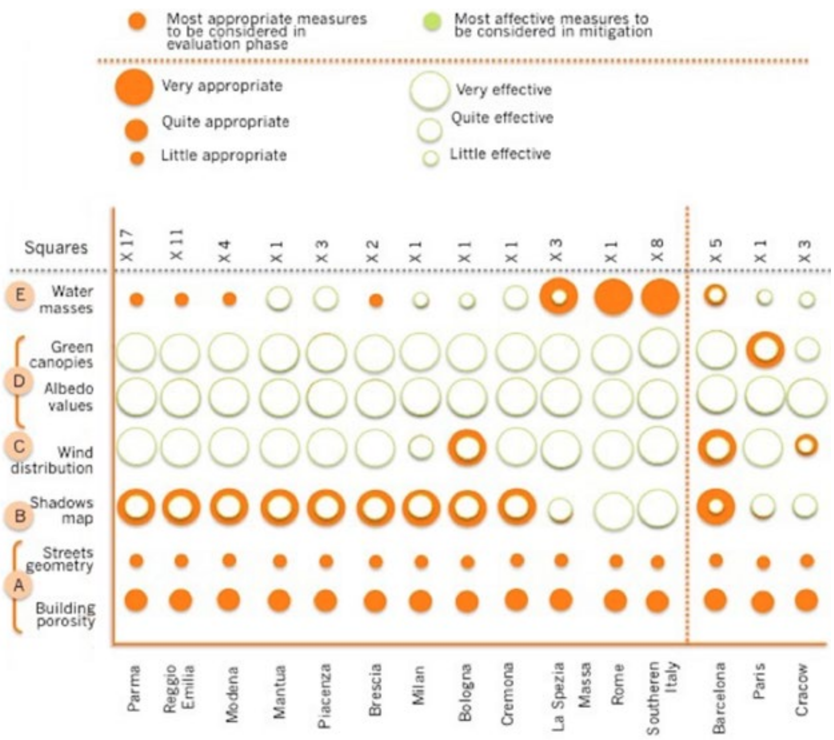


Figure 7. Case studies overview

The campaign has been conducted since 2012, involving master degree students in Architecture, whose targets were to investigate the actual microclimatic conditions in several cities in Italy and in Europe, for a gross amount of 106 study cases.

Table 2. Case studies overview

Cities	Number of study case	Action category involved	Most Appropriate Action category	Most Effective Mitigation Strategies
Parma (IT)	17 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Reggio Emilia (IT)	11 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Modena (IT)	4 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Mantua (IT)	1 square	1-2-3-4-5	A; B; C; D;	B; C; D
Piacenza (IT)	3 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Modena (IT)	4 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Brescia (IT)	2 squares	1-2-3-4-5	A; B; C; D;	B; C; D
Milan (IT)	1 square	1-2-3-4-5	A; B; C; D;	B; C; D
Bologna (IT)	1 square	1-2-3-4-5	A; B; C; D;	B; C; D
Cremona (IT)	1 square	1-2-3-4-5	A; B; C; D;	B; C; D
LaSpezia (IT)	3 squares	1-2-3-4-5	A; B; C; D; E;	C; D; E
Massa (IT)	1 square	1-2-3-4-5	A; B; C; D; E;	C; D; E
Rome (IT)	1 square	1-2-3-4-5	A; B; C; D; E;	C; D; E
Southern Italy (IT)	8 cities	1-2-3-4-5	A; B; C; D; E;	C; D; E
Barcelona (ES)	5 squares	2-3-4-5	A; B; D; E;	B; C; D; E
Cracow (PL)	3 squares	2-3-4-5	A; B; C; D;	B; C; D
Paris (FR)	1 square	2-3-4-5	A; B; C; D;	B; C; D

Implementing resource efficiency and climate sensitivity in existing urban environment requires a factual integration of highly complex urban conditions that need to be merged to legislative and historical constraints. Planning processes for resource-efficient and climate-sensitive neighbourhood or urban design have been demonstrated viable, in case of dense cities and neighbourhood, by intervening on a microclimatic scale, assessing firstly the local microclimate and then considering the elements that can be easily added or modified, as green belts, shelters for sun shading and surface materials to be changed, without altering the overall aspect of the city itself. As reported in the 4th and 5th columns, every microclimatic conditions and topographic features lead to different approaches or strategies to be adopted.

Amidst different strategies to overcome barriers to decarbonising cities, an effective strategy can be thus played by bioclimatic design and passive systems to get to a low carbon, resilient cities, without altering the established city's layout.

All these results aim at demonstrating that monetary resources can be valuable to build efficiency in responding climate challenges, but even a climate sensitive urban redesign could be extremely successful and money saving though, considering, for the first time the city itself as a decarbonizing lever.

The design approach hereby proposed can be considered as an alternative scenario in order to improve microclimatic urban condition thanks to an Environmental Assessment Method For Decarbonised Urban Renewal, by promoting all form of passive natural devices, by increasing permeable surfaces or by modifying the albedo values of finishing materials used and, eventually, improving natural cooling and minimising unwelcome solar heat gains.

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SUSTAINABLE NEIGHBOURHOODS RETROFITTING

Applying FASUDIR indicators to assess the sustainability performance of a residential neighbourhood in Wolfrathausen, Bavaria

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key performance indicators

Abstract

In comparison to the traditional single building retrofitting, the neighbourhood retrofitting approach is frequently cited as the most sustainable and cost-effective retrofitting option. However, applying the neighbourhood approach usually leads to an exponential growth of the complexity of the decision making process as the interventions affect a wider number of stakeholders.
In the elective course "Sustainable Neighbourhoods" undergraduate students of the faculty of Architecture at Munich University of Applied Sciences in cooperation with the city of Wolfratshausen, have tested the validity of the neighbourhood approach on a real case study site using on-site collected data and GIS files and FASUDIR (Friendly and Affordable Sustainable Urban District Retrofitting) key performance indicators (KPI's) to assess the sustainability performance of the neighbourhood and developed a number of viable retrofitting scenarios.

1_Introduction

The European building sector is responsible for 40% of overall energy consumption sector half of it is used for Heating, cooling and ventilation (1). With more than 70% of the building stock built before the first energy crisis (1970's), energy retrofitting of buildings represents the largest and the most effective untapped source to reach the EU's "40-27-27" targets (2). However, the results of current practice of retrofitting projects have shown that in order to fully exploit the potentials of retrofitting the existing building stock each building need to be investigated within its context in the neighbourhood and as a part of a global system in a district. This approach requires treating each individual building not as a standalone building but in relation to its context, where all the buildings within the neighbourhood are treated as a single entity. In this case, applying a chosen retrofitting measure is not limited to single building scale but can be applied on whole neighbourhood aiming at elevating the ecological, economic and social aspects of the development, through exploiting synergies and interactions between buildings and their surroundings.
However, applying the neighbourhood approach usually leads to an exponential growth of the complexity of the decision making process as the interventions affect a wider number of stakeholders who usually lack a common view on the current state of the neighbourhood and/or a common goal. Therefore, having a quick and accurate assessment of the current and the post-retrofiring performance of a neighbourhood is crucial for the success of the neighbourhood approach, as it provides the stakeholders with a better insight into a state of the neighbourhood and helps them to define a common retrofitting goal.
Although the neighbourhood approach appears to be very promising, there is really a limited number projects that can show the advantages of the neighbourhood retrofitting and even more limited number of holistic planning tools and assessment systems such as FASUDIR and District ECA that are specially designed for such project.
In the winter semester of 2014/15 in the course "Sustainable Neighbourhoods" the students of the faculty of Architecture at Munich University of Applied Sciences in cooperation with the city of Wolfratshausen, have been

introduced to the neighbourhood approach of retrofitting and were given the chance to test the validity of the neighbourhood approach on a real case study site using on-site collected data, GIS files, the methodology and a set of Key performance indicators developed by FASUDIR and District ECA software. The results of the current state assessment and the retrofitting scenarios are then compared to each other and documented in the final report, which was later presented to the mayor of Wolfratshausen.

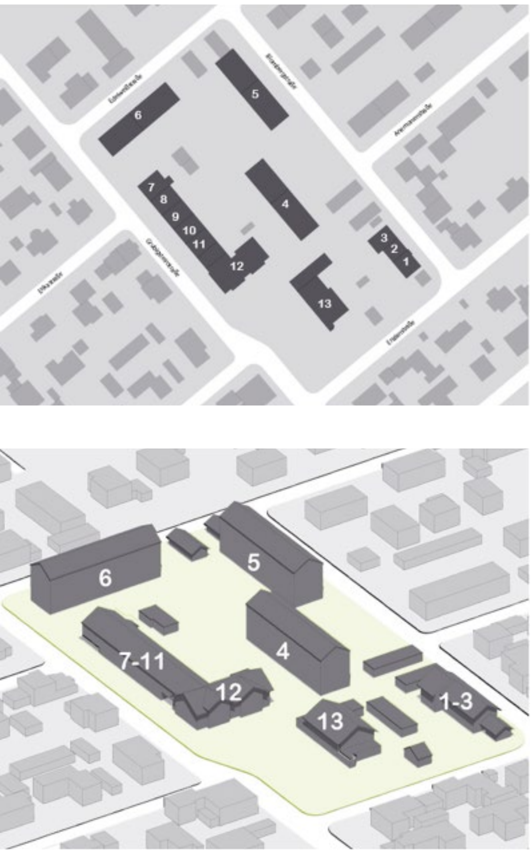

Figure 1. Site plan and 3D visualisation of the case study site (Khoja 2014)

1.1_Case Study Site

The case study site was identified by the city of Wolfratshausen as a suitable site to conduct the sustainability assessment with the aim for the site to be a pilot case for testing the neighbourhood retrofitting approach in the future. The chosen residential neighbourhood is located in the district of Farchet, which is one of the five districts of the city of Wolfratshausen. The city of Wolfratshausen is located at the border of the German Alps, some 35 Km to the south of Munich, the capital city of the federal state of Bavaria.

The area of the site is about 1.5 Hectares and is dominated by multi story buildings that mostly date back to the 1960's. Most of the buildings in the site are for residential purpose only, however some commercial spaces occupy the ground floor of the row housing development on the south east side of the block . A restaurant dating back to the early 1900s is located within a public green space at the south east side of the block. The site is home to some 210 inhabitants. The vast majority of the buildings are connected to the local Gas supply network, one building uses wood pallets with the rest relaying on oil fuel for their heating demand.

Table 1. Summary of the buildings in the case study site

Building Number	Use	Construction Year Class	Energy Source	Net Floor Area	Roof Orientation and Area
1	Single Family house	1969-1983	Gas	239,2 m²	SW 52,7 m² NE 50,2 m²
2	Single Family house	1995-2006	Gas	173,3 m²	SW 38,6 m² NE 36,3 m²
3	Single Family house	1984-1994	Gas	252,3 m²	SW 53,2 m² NE 53,4 m²
4	Apartment block	1949-1968	Gas	1756,3 m²	SW 252,8 m² NE 252,8 m²
5	Apartment block	1949-1968	Gas	1757,1 m²	SW 253 m² NE 252,8 m²
6	Apartment block	1949-1968	Oil	1744,3 m²	SE 251,7 m² NW251,7 m²
7	Mixed: Bank and Row housing	1977-1983	Gas	123,8 m² 216,7 m²	SW 66,5 m² NE 79,6 m²
8	Mixed: shop and Row housing	1949-1968	Gas	101,3 m² 177,3 m²	SW 59,1 m² NE 59,2 m²
9	Mixed: Office and Row housing	1949-1968	Gas	99,7 m² 174,5 m²	SW 58,2 m² NE 58,2 m²
10	Row housing	1949-1968	Oil	274,3 m²	SW 58,2 m² NE 58,2 m²
11	Office	1977-1983	Gas	278,7 m²	SW 59,3 m² NE 59,3 m²
12	Multi Family house	2007-2012	Wood pallet	1218,6 m²	SW 81,5 m² NE 80,2 m²
13	Restaurant	1900-1948	Gas	675,4 m²	SW 122,2 m² NE 133 m²

1.2_Methodology

The students' task was to assess the sustainability performance of the neighbourhood in its current state and to develop viable retrofitting scenarios aiming at improving the neighbourhood overall sustainability performance using a selection of FASUDIR KPI's for benchmarking.
To carry out this task the students were provided with a CityGML file of the case study site made available courtesy of the Bavarian State Office for Survey and Geoinformation and were briefed about the case study site condition, location from a representative of the municipality Wolfratshausen. Due to the time and resources limitation only a limited number of the Kip's where to investigated in this study. The following table presents summary of the used FASUDIR KPI's in the performance assessment of the neighbourhood in its current state and after retrofitting, along with the method used to calculate achieved points of each KPI (3).

Table 2. Summary of the used FASUDIR KPI's

Level	Category	Indicator	Sub-Indicator	Calculation method
District	Environmental	Energy demand	Operational Energy Use	Aggregation of the building level results
District	Environmental	Energy demand	Share of Renewable Energy on Site	District ECA Software, aggregation of the building level results
District	Environmental	Impact on the Environment	Global warming potential (GWP)	District ECA Software, aggregation of the building level results
District	Social	Motor transport infrastructure	Parking facilities	On site collected data
District	Social	Motor transport infrastructure	Infrastructure for innovative concepts	On site collected data
District	Social	Public transport infrastructure	Internal Accessibility	Google maps and on site collected data
District	Social	Bicycle and pedestrian	Bicycle facilities	On site collected data
District	Social	Accessibility	Barrier - Free Accessibility	On site collected data
District	Social	Accessibility	Access to services and facilities	Google maps and on site collected data
District	Social	Accessibility	Access to parks and open spaces	Google maps and on site collected data
District	Social	Thermal comfort	Heat Island	Google maps and on site collected data and GIS data
District	Economic	Life cycle cost	Running Costs Energy	Aggregation of the building level results

2_Current state analysis

The results of the current state analysis have showed that the neighbourhood with its 9.747,90 m² of net floor area has a total primary energy demand of 2943 MWh/a and emits 745 T/a of CO² equivalent of emissions. The net floor area of the buildings is calculated using:

$$NFA = \text{Building footprint} \times floors \times 0.8 \text{ (gross to net factor) (8)} \quad (1)$$

The total primary energy demands along with the amount emitted emissions are calculated using the default values in the District ECA. The default values are derived from the average energy consumption per square meter according to the construction year class of the buildings and CO² equivalent emission of the energy sources using the primary energy factor in the calculation. The share of renewable energy in the neighbourhood is about 9%.

For assessing the indicator operational energy use in the district the results of the operational energy use indicator of each building are aggregated to cover the neighbourhood , the assessment is then done using the following FASUDIR formula (3):

$$PE_{op} \div PE_{op}/_{lim} = 0\% = 100 \text{ Point} \qquad (2)$$

With the PE limit = 200 kWh/m².a. The running energy costs of the neighbourhood account for 154.388€/a based on the price of wood palltes at 5,5ct/kWh, natural gas at 7,7ct/kWh and fossil oil at 8,36 ct/kWh (4).

Figure 2. Calculated current operational energy Use for each building in the case study site (Khoja 2014)

(r) residential
(o) office
(b) bank
(g) gastronomy

energy use in MWh/a

Figure 3. Impressions taken from the case study site (Khoja 2014)

Category	Sub-Indicator	Points achieved from 100
Environmental	Operational Energy Use	0 Points
Environmental	Share of Renewable Energy on Site	45 Points
Environmental	Global warming potential (GWP)	No benchmark available
Social	Parking facilities	38 Points
Social	Infrastructure for innovative concepts	0 Points
Social	Internal Accessibility	100 Points
Social	Bicycle facilities	25 Points
Social	Barrier - Free Accessibility	100 Points
Social	Access to services and facilities	75 Points
Social	Access to parks and open spaces	100 Points
Social	Heat Island	50 Points
Economic	Running Costs Energy	No benchmark available
Total		53.4 / 100 point

Table 3. Summary of current state analysis results

3_Analysis of the retrofitting variants

Out the nine analysed retrofitting scenarios, three are presented in this paper and are given the codes Variant 1, 2 and 3. All retrofitting scenarios were investigated in terms of their impact on the environmental as well as the economical KPI's of the neighbourhood. The three variants address retrofitting the building system as well as the building envelope. Variant 1 and 2 present the scenarios where the building envelope is retrofitted to meet the minimum requirements of the German Energy Saving Ordinance (EnEV) of 2014 (5). Variant 3 presents a scenario where the building envelope is retrofitted to meet the requirements of the passive house standard (5). Variant 2 uses a gas driven district heating system in order to meet the demand of space heating, thus representing a district solution, while Variant 1 and 3 use a gas driven condensing boiler and geothermal heat pump respectively, thus representing a single building solution. The Table 3 provides a summary of the investigated retrofitting parameters. The social KPI's Infrastructure for innovative concepts and Bicycle facilities are considered in the three variants to be retrofitted to achieve the maximum points. The KPI result of the other social aspects: parking facilities, heat island and access to services and facilities are not changed from the current state analysis as they are beyond the scope of this limited study. The KPI Running costs and the KPI Global warming potential (GWP) were not considered in the assessment, as at the time of conducting this study no benchmarking for these KPI's is published (3).

Table 4. Summary of retrofitting measures parameters

		Variant 1	Variant 2	Variant 3
Building systems	Space heating	Condensing boiler	District heating	Geothermal heat pump
	hot water	Solar thermal	District heating	Solar thermal
	Ventilation	Window	Window	Heat recovery DC 75%
	PV	10% of available & suitable space	10% of available & suitable space	40% of available & suitable space
Building envelope	Windows	U = 1,3 W/(m².K)	U = 1,3 W/(m².K)	U = 0,8 W/(m².K)
	Exterior wall	U = 0,24 W/(m².K)	U = 0,24 W/(m².K)	U = 0,11 W/(m².K)
	Top floor ceiling/Ceiling to attic	U = 0,3 W/(m².K)	U = 0,3 W/(m².K)	U = 0,07W/(m².K)
	Floor slab	U = 0,4 W/(m².K)	U = 0,4 W/(m².K)	U = 0,12 W/(m².K)
	basement ceiling	U = 0,35 W/(m².K)	U = 0,35 W/(m².K)	U = 0,25 W/(m².K)

3.1_Results of analysis

The results of the variants analysis show that Variant 3 with its passive house standard insulation is the most energy saving option but also the most expensive one in terms of initial investments as well as running costs, with the electricity costs being calculated at 28,8ct/kWh (6). Variant 1 consumes about double as much energy as variant 3 however, it costs half as much to run. In comparison, variant 2 appears to be the most balanced option between both variants as it achieves a very good saving level in terms of energy demand, it fulfils the /renewable energy goal of 20% and its running costs are marginally higher than of Variant 1 with the running costs of district heating calculated at 9,2ct/kWh (7).

Table 5. Summary of variants performance

Sub-Indicator	Variant 1	Variant 2	Variant 3
Operational Energy Use	1418 MWh/a = 28 Pt	1238 MWh/a = 37 Pt	781 MWh/a = 60 Pt
Share of Renewable Energy on Site	24%= 100Pt	20% = 100 Pt	50% = 100 Pt
Global warming potential (GWP)	352t/a	345 t/a	219 t/a
Parking facilities	38 Points	38 Points	38 Points
Infrastructure for innovative concepts	100 Points	100 Points	100 Points
Internal Accessibility	100 Points	100 Points	100 Points
Bicycle facilities	100 Points	100 Points	100 Points
Barrier - Free Accessibility	100 Points	100 Points	100 Points
Access to services and facilities	75 Points	75 Points	75 Points
Access to parks and open spaces	100 Points	100 Points	100 Points
Heat Island	50 Points	50 Points	50 Points
Running Costs Energy	109 186 €/a	113 896 €/a	224 928 €/a
Total	69.1	70	73.1

3.2_Comparison of the results of current state to the retrofitting variants

Table 6. Performance of current state vs. variants

Sub-Indicator	Current state	Variant 1	Variant 2	Variant 3
Operational Energy Use	2943 MWh/a	- 52%	- 58%	-73.4%
Share of Renewable Energy on Site	131.7 MWh/a	+ 132%	+ 131.2%	+ 241%
Global warming potential	745	- 52.7%	- 53.7%	- 70.6%
Parking facilities	97 off street	0%	0%	0%
Infrastructure for innovative concepts	148 on street	0%	0%	0%
Internal Accessibility	100 Points	0%	0%	0%
Bicycle facilities	25 Points	+ 300%	+ 300%	+ 300%
Barrier - Free Accessibility	100 Points	0%	0%	0%
Access to services and facilities	75 Points	0%	0%	0%
Access to parks and open spaces	100 Points	0%	0%	0%
Heat Island	50 Points	0%	0%	0%
Running Costs Energy	154.388€/a	-29.2%	-26.2%	+54.7%
Total	53.4 Pt	+ 29.4%	+31%	+37%

4_Review on FASUIR Key performance indicators

FASUDIR Key performance indicators are unique in their nature as they are designed to for district retrofitting projects which is a very complicated task, also the FASUDIR KPI's are developed to be applicable in three very different European countries namely, Germany, Hungry and Spain. Applying the

FASUDIR KPI's to this case study has provided a valuable insight into the way the KPI indicators preform, their advantages, their short comings. Thus the following table provide a review on the indicators:

Table 7. Review on applied FASUDIR KPI's

Sub-Indicator	Shortcoming/suggestions
Operational Energy Use	The current calculation doesn't allow to use different benchmarks for different building types and use
Share of Renewable Energy on Site	The share of renewable energy on site can be very challenging to estimate especially with tall buildings and/or outdated satellite images
Parking facilities	Access to underground / off street parking is not always granted to the planner
Infrastructure for innovative concepts	The indicator doesn't take into account the free floating car sharing concepts which do not require a dedicated parking space
Bicycle facilities	The four facilities are giving the same weighting which might need to be reconsidered, as having a bike path can be more important than to have built protection against theft. The method of calculation the four facilities on a district scale is not clearly explained
Barrier - Free Accessibility	The indicator doesn't specify for each type of disability the required type of Barrier-free, such as the enabling a deaf person using a traffic light
Access to parks and open spaces	The indicator doesn't specify a minimum area for a green space so the green space is considered sufficient for the district. Setting green area per inhabitant threshold might help overcome this short coming
Heat Island	The indicator deliver a qualitative result, that doesn't not give a clear indication between the anticipated comfort level and the resulted heat island

5_Conclusion

In this paper, the results of applying neighbourhood approach for retrofitting the existing building stock as well using the FASUDIR district KPIs on pilot real case study are presented. A critical review on the performance of FASUIR KPI's for district level along with suggestion for improvement the KPI's for further use are discussed.

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UNDERSTANDING VARIATION IN BUILDING ENERGY ANALYSES:

using extant literature to explain policy outcomes

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Abstract

Benchmarking energy and water consumption is a policy option increasingly being adopted by cities with the goal to manage the environmental impact of buildings. The potential impacts of this policy type are twofold: Based on the role of information in behaviour change and market theories, building owners, operators and occupants are expected to change their energy consumption behaviours as new information is made available to them. Second, measurement of policy and program impact will improve as the same size of building energy data increases and becomes more representative for city-level analysis. Using a meta-regression methodology (a type of meta-analysis), this research reviews extent energy efficiency program analyses to test for systematic variation across studies to explain variation in energy analyses at the program level. The intent is to inform projections of energy impacts from new benchmarking policies using generalizable results from the regression. The regression results show statistically significant effects of systematic variation in original studies, including type of publication, number of buildings in the model, methodology used for calculating program impact, and outlier building types. City-level policy analysts will consider the effects of these factors when using an original study as the basis for policy impact projections.

1_Introduction

The buildings sector has major environmental impacts, accounting for 32% of the world's energy use and 19% of the world's greenhouse gas emissions from energy-related activities (Lucon et al., 2014). Various policy instruments have been adopted over the previous few decades with the intent to reduce environmental impacts from the buildings sector. Programs include design standards that also serve as eco-labels and information disclosure mechanisms, such as the U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) and U.S. Environmental Protection Agency (EPA) Energy Star for Buildings programs. With an emphasis on data-driven policymaking, benchmarking building energy and water consumption is a policy type increasingly being adopted by cities throughout the United States (Palmer and Walls, 2014).

Community-level policy analysts often use basic estimations to project potential policy impact for sustainability and energy planning purposes (Patton and Sawicki, 1986). Estimations are often based on results of one study or dataset. For energy programs, the EPA recommends the following basic calculation:

$$\hat{y}_{energy\ savings} = ((\hat{x}_{subject} - \hat{x}_{baseline}) \pm \text{adjustments}) \qquad (1)$$

where $\hat{y}_{energy\ savings}$ is the policy impact for the affected population, $\hat{x}_{subject}$ is the energy usage of buildings subject to the program, $\hat{x}_{baseline}$ is the energy usage of baseline (code-built) buildings (U.S. EPA, 2015a). This formula is more basic than those used at the facility or measure level in engineering studies, which commonly use the International Measurement and Verification Protocol (Efficiency Valuation Organization, 2014) or ASHRAE Guideline 14

(ASHRAE, 2014), or formulas for measuring benchmarking policy impact after the policy is implemented (Navigant Consulting, Inc. and Steven Winter Associates, 2015). Community-level policy analysts often adopt results of published studies due to lack of resources or a long enough time frame to conduct field experiments for the purposes of forecasting.

A convention in the energy efficiency program field is to report results in terms of percentage of energy savings:

$$\hat{y}_{\text{energy savings}} = \left(\left(\frac{\hat{x}_{\text{subject}} - \hat{x}_{\text{baseline}}}{\hat{x}_{\text{baseline}}} \right) \times 100 \right) \pm \text{adjustments} \;) \tag{2}$$

In the Data Trends series, the EPA reports 2.4% annual energy savings from benchmarking in an analysis of 35,000 buildings that benchmarked using EPAs Portfolio Manager software (U.S. EPA, 2015b). A bias of this dataset when applying the results to local policy impact projections is that most of the buildings voluntarily benchmarked to track changes in energy consumption caused by building retrofits, whereas buildings motivated to benchmark as a local policy requirement may be less likely to pursue subsequent retrofits. Therefore, in a local policy context, a negative adjustment is necessary in the aforementioned energy savings calculation.

This research uses a meta-regression methodology to analyse the characteristics of a set of studies to test for systematic biases in original studies to inform adjustments in local benchmarking policy impact projections. The intent of this exercise is to inform the policy analyst's decision to adopt results from a study (in this case, the percent change in energy use) as the basis for program impact projections, with an understanding of systematic factors that explain variation in reported results. A co-benefit of this study is that it provides insights into debates about whether LEED buildings perform better than conventional buildings, moving beyond anecdotal discussions that attribute variation to LEED credit choice, occupancy factors and building modelling errors. The methodology applied in this study is encouraged to be used in other policy domains where there is a desire to understand why variation across studies exists.

Beginning with a literature review, I reveal that the scholarly energy efficiency field is concerned with two very different aspects of benchmarking policies. Some focus on the analytical and methodological aspects of environmental benchmarking while others are more concerned with the effect that benchmarking has on energy and water consumption, relying on the theory of the role of information as a catalyst for market transformation and behaviour change. This research tackles the two complementary technical and theoretical concerns within the energy efficiency field, presenting the distinct viewpoints as a mutual issue. I build a meta-regression equation that incorporates variables for each viewpoint from studies that measure commercial building energy program impact. The dependent variable in the meta-regression equation is percent change in energy use, caused by a program intervention and explained by analytical and methodological aspects of the original studies.

2_Literature Review

2.1_Benchmarking Energy Consumption

The accuracy of benchmarking is critical to policy analysis as benchmarks serve as baseline for comparison with a group of peer buildings subject to a program intervention. Most commonly, researchers use Ordinary Least Squares (OLS) multiple linear regressions to predict Energy Use Intensity (EUI) based on building characteristics and environmental factors (Lee, 2012). The user interface is commonly a percentile table or scale that ranks buildings compared to energy use of the peer buildings group, determined using a regression model (Chung, Hui, and Lam, 2006).

Efforts have been made to improve benchmarking models. Stochastic Frontier Analysis (SFA) has been used to separate actual technical energy inefficiencies from the error term in the regression model (Chung, 2011, p. 1473). Stepwise linear regression has been used to include the most significant variables in the model to improve accuracy (Sharp, 1996; Xuchao, Priyadarsini and Eang, 2010). Other techniques, such as Data Envelopment Analysis (DEA) (Zhou and Ang, 2008) and Artificial Neural Networks (ANN) (Yalcintas and Ozturk, 2007) are two innovations in benchmarking, but are more appropriate for internal as opposed to public benchmarking (Chung 2011). The intent of public benchmarking is to understand building performance compared to a peer group whereas the intent of internal benchmarking is to compare the building to itself over time (Chung, 2011).

2.2_Information as a Catalyst for Change

Information has an effect on market transformation, behaviour change in individuals, and policy change. Accordingly, governments have been designing mandatory policies and voluntary programs for information disclosure (Lee, 2012). These policies and programs attract participation by corporations, universities, individuals, and governments entities that engage for a variety of reasons. In an environmental context, polluters want to avoid negative publicity and pressure exerted by investors and community activists (Palmer and Walls, 2015; Khanna, Quimio and Bojilova, 1998). Threats of subsequent regulation may prompt voluntary behaviour change (Demas, Montes-Sancho and Shimshack, 2010, p. 487). To be effective, it has been argued that information needs to be embedded in everyday life and personalized for each stakeholder group (Weil, Fung, Graham and Fagotto, 2006) and consumers of information need the appropriate levels of expertise to process information (Weil et al., 2006; Demas et al., 2010, p. 484; Starkey et al., 2013; Hsu, 2014). Economic theory posits that a benefit of information is that it reduces asymmetry by creating more knowledgeable consumers which changes purchasing behaviours (Cohen & Viscusi, 2012) while improving market efficiencies by lowering transaction costs otherwise incurred when buyers are uninformed (Kontokosta, 2013). Regarding energy benchmarking specifically, Hsu (2014) concludes through regression modelling that benchmarking provides the appropriate level of information to predict building energy performance compared to engineering audits. In sum, information is widely regarded as a catalyst for change.

2.3_Measuring Program Impact

2.3.1_Technical Issues

The issue of model accuracy has gained attention as more post-program intervention data becomes available. When a new program is launched, field observations (actual energy data collection and analysis) are not possible because multiple years of program activity is needed to measure effects of the program intervention. Consequently, modelling simulations are used to project energy savings from buildings using the above-code program design standards compared to code-built buildings, presenting the difference of means as the output. The uncertainty and inconsistencies of modelling simulations surface when energy usage is verified with actual data, and buildings over or under perform. For example, Stoppel and Leite (2013) found that the modelling simulation over-predicted building energy use for two buildings by 14% and 25%. Schwartz and Raslan (2013) found that the use of particular simulation tool or statistical model significantly affect the reported results. After the program has been in operation over time, field observations (actual energy data collection) are often used and compared to a baseline such as the Commercial Building Energy Consumption Survey (CBECS). In the EPAs estimate of benchmarking policy impact, the agency was able to compare field observations to field observations as a time series dataset, which is the optimal building energy data analysis method.

Another issue in building energy analyses is inconsistent variables included in original models. Building type and weather are two variables that are generally well understood, while occupancy factors show the most unexplained effect on building energy use. Occupant factors have historically been difficult to model (Ryan and Sanquist, 2012), but commonly are cited as a critical missing link to predicting building performance (Hsu, 2014; Kaddory Al-Zubaidy, 2015). Operationalization of occupant factors include indoor set point temperatures, maintenance schedules, operating hours of the building, and number of employees. In a cluster analysis using energy simulations of LEED office buildings, Heidarinejad, Dahlhausen, Mahon, Pyke, and Srebric (2014) find that unregulated process loads, such as server equipment and plug loads, account for the most variation between office building clusters. Occupant factors and process loads are difficult to model and regulate.

Type of energy is another important measurement issue. Some argue that energy savings from LEED buildings are incorrectly measured using site rather than source energy (Scofield, 2013). Scofield (2013) re-ran variations of the models that New Buildings Institute (2008) and Newsham, Mancini and Birt (2009) had produced, and found significantly less energy savings using source energy as the unit of analysis. Site energy is the amount of energy used by the building, seen as units of energy consumption on utility bills. Source energy is the true amount used by the building including the energy needed for generation and transmission. Source energy is a more holistic way of calculating building energy usage, but site energy is more commonly analysed in building energy efficiency studies for various reasons. However, source energy is more applicable to broader energy policy and utility planning.

2.3.2_Political Issues

Agency bias is expected to cause differences in policy analysis from a theoretical basis, as the dual role of an individual as policy analyst and advocate is blurred (Fischer and Forester, 1993; Roe, 1994). For example, an environmental advocacy organization may need to express high environmental impact of a program that they support or developed. Accordingly, program designers and analysts may have a motive to present the best-case scenario of potential program impact. The vantage point of the analyst or author is a necessary consideration as decisions are consistently made throughout the process of statistical analysis, causing modifications in statistical results.

3_Methodology

3.1.1_Search Strategy

I adopted literature search methods used in other buildings-related energy efficiency meta-analyses (Delmas et. al., 2013; Ankamah-Yeboah and Rehdanz, 2014). First I searched EBSCO Host and Web of Science databases using the following search settings: 1975-2015; English language; keywords with Boolean operators:

("energy use" OR "greenhouse gas*" OR "air pollution") AND ("LEED" OR "Energy Star" OR "eco-label" OR "Time of Sale" OR "inventory" OR "benchmark" OR "Portfolio Manager" OR "audit") AND building*

For each paper that was retrieved in the initial sweep, I also downloaded "recommended" or "relevant" articles automatically generated by the database during the article download process. I eliminated articles based on the title if it explicitly stated that the article focus was residential buildings or transportation, or some other unrelated topic. Next, I read abstracts to determine if the paper was quantitative and focused on a change in environmental metrics as a result of a program intervention. After reading each full article, studies were eliminated due to insufficient statistical information or wrong unit of analysis.

Much of the variation in policy type and location had been removed through the process of article elimination. Through the initial search, I identified a few additional eco-labels that should have been included in the analysis. Accordingly, I revised the Boolean search string and searched in the Google Scholar database.

("energy use intensity") AND ("BREEAM" OR "EPBD" OR "CASBEE" OR "BEAM Plus" OR "ESGB" OR "Energy Star" OR "Green Mark" OR "Green Star" OR "Display Energy Certificates") AND "commercial building*" AND "statistic*"

The search string now focuses on a clear dependent variable in the original studies – Energy Use Intensity – and expands the search for policies and programs. Finally, 14 articles containing 168 statistical models were included in the meta-regression (Table 1).

Article	# Models per Study
Burpee and McDade (2014)	8
Chen, Lee and Wang (2015)	8
New Buildings Institute (2008)	22
Newsham, Mancini and Birt (2009)	16
Oates and Sullivan (2011)	19
Scofield (2013)	10
Scofield (2009)	6
Menassa, Mangasarian, El Asmar and Kirar (2012)	22
Agdas, Srinivasan, Frost, and Masters (2015)	2
Torcellini, Deru, Griffith, Long, Pless, Judkoff and Crawley (2004)	7
Webster, Bauman, Dickerhoff and Le (2008)	2
Cipriano and Carbonell (2007)	1
Diamond, Opitz, Hicks, Neida and Herrara (2006)	31
Turner and Frankel (2008)	14
N (Observations)	168

Table 1. Studies Used in this Analysis.

3.1.2_Description of the Data

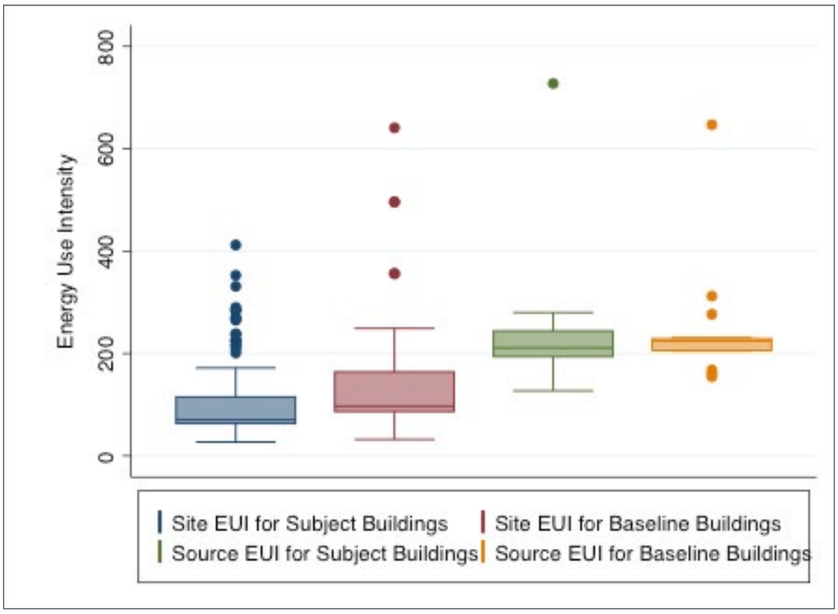
A heterogeneity test is performed to analyse variation between the effect sizes, which is necessary for the meta-regression. The dependent variable in this study is percent change in energy use, measured by comparing the energy use intensity of a subject building(s) to a baseline building(s). A t-test was conducted to verify variation in the means of EUI of the subject and baseline buildings (Table 2). The paired t-test was used because each subject building was matched with a baseline building in the original study, representing the EUI before and after the program intervention. In many of the original studies, the researcher performed matching techniques to pair a set of buildings to one subject building. Using the paired t-test, each set of baseline and subject buildings are treated as a pair. The difference of -24.83% rejects the null hypothesis that H_0: $\mu \neq \mu_0$, or the mean of the two groups is the same. The upper and lower bounds of the 95% confidence interval are -34% and -15%, respectively. The t-ratio (-5.55) represents the mean difference divided by the standard errors.

Variable	Obs	Mean	Std. Err.
Site EUI Baseline Buildings	119	105.8	6.93
Site EUI Subject Buildings	119	130.64	8.25
Difference	119	-24.83	4.47
t = -5.55			
df = 118			

Table 2. Paired T-test of Site EUI for Baseline and Subject Buildings.

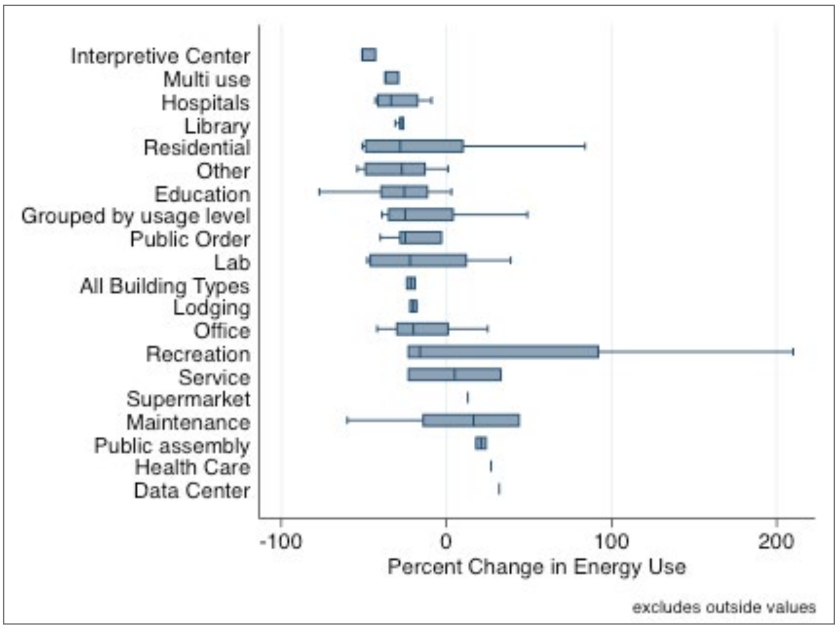
Finding sufficient variation between pairs, a boxplot is used to depict the distribution of the reported EUI in the original studies (Figure 1). The bottom and top of the boxes are the first and third quartiles, while the line in the middle represents the second quartile. This particular boxplot uses Tukey's methods as the robust measure of scale. As such, the whiskers represent the interquartile range (IQR) depicting the difference between the upper and lower quartiles of the data. The dots represent outliers.

Figure 1. Box plot of energy use intensity for subject and baseline buildings.



Because of the results in Figure 1, a second boxplot was developed to identify if certain building types were chiefly responsible for the outliers (Figure 2). The greatest variation was found in multi-family residential and recreation building use types.

Figure 2. Box plot of percent change in energy use by building type.



The analytical intent of this study is to understand systematic variation in original studies. Independent variables of interest regarding systematic variation include publication type, data collection, program type, building location, and building use type. Journal, program, and building use type where aggregated into dummy variables: LEED or non-LEED, academic or non-academic, and office or non-office. Table 3 shows that the distribution of academic and non-academic articles is fairly even, whereas the program type is overwhelmingly LEED. The reason for so many LEED studies compared to other program types is unknown, as the search strategy explicitly called for other programs. Reasons include the limitation to articles written in English and lack of studies on this type of program impact.

Table 3. Descriptive Statistics for Categorical Variables.

	Freq.	Percent	Cum.
Publication Type			
Non-academic	74	44.05	44.05
Built Environment	38	22.62	66.67
Policy	28	16.67	83.34
Engineering	20	11.9	95.24
Health	8	4.76	100
Program Type			
LEED	146	86.9	86.9
Energy Star	10	5.95	92.85
Zero-Energy Buildings	7	4.17	97.02
BEAM Plus	4	2.38	99.4
ICLEI Current Procura	1	0.6	100

A total of 168 observations from 14 studies are included in the meta-regression (Table 4). Some studies had multiple models (min=1, max=31) and some models included multiple buildings (min=1, max=121). Ninety percent of models are of buildings in the United States, and 30% are office buildings. Seventy-seven percent of the models use field observations as the measurement method, with the remaining 23% using modeling simulations. Again, field observations use actual building energy data while modelling simulations use estimations based on design characteristics. Fifty-five percent of the models used data from the Commercial Building Energy Consumption Survey (CBECS) as the baseline dataset. Eighty-nine percent of the models used site energy and 11% used source energy as the type of energy. Eighty-seven percent of the models used EUI as the energy unit, while 13% used electricity (kilowatt hour per square foot)[1].

[1] Models using electricity energy units were only included as percent change in energy use, which normalizes the differences with studies that used EUI as the energy unit.

Table 4. Descriptive Statistics for Continuous and Categorical Variables.

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
(a) Percent Change in Energy Use	All Observations	168	-10.36	48.21	-252	235
(b) Percent Change in Energy Use	Only Site EUI	130	-18.85	27.81	-77	109
Measurement Method	Field Measurement=1, Modeling/Simulation=0	168	0.77		0	1
Program Type	LEED=1, non-LEED=0	168	0.87		0	1
Model Compared to CBECS	yes=1, no=0	168	0.55		0	1
Type of Energy Use	Site=0, Source=1	168	0.11		0	1
Energy Use Intensity (kBTU/sqft)	Subject Buildings, Site Energy	121	104.87	75.39	27	412
	Baseline Buildings, Site Energy	119	130.64	130.64	32	641
	Subject Buildings, Source Energy	16	243.14	135.48	127	728
	Baseline Buildings, Source Energy	16	244.97	114.09	154	647
Energy Unit	EUI=0, Electricity=1	168	.13		0	1
Building Type	Office=1, Other=0	168	0.30		0	1
Building Location	United States=1, Other=2	168	0.92		0	1
Year of Publication		168	2009	3.03	2004	2015
# Buildings in Model		168	11.64	21.21	1	121
# Models in Study		168	12.00	8.98	1	31

The null hypothesis reflects the idea that the programs do not achieve energy savings, which was rejected by the paired t-test in the previous section. Regarding the meta-regression, directional statements are developed regarding the effect of systematic variation in original studies on the dependent variable, percent change in energy use (Table 5). The type of publication is expected to have an affect on the effect size, as energy savings reported by agencies that develop the program are expected to be systematically biased. This proposition has been purported by academics who have questioned the statistical results in agency reports (e.g., Scofield, 2009; Scofield, 2013). Models that use CBECS as a baseline are expected to report higher energy savings than those that use building codes because CBECS is more outdated. Note, CBECS is commonly used as a baseline when the field measurement methodology is used, whereas building codes are more commonly used as a baseline in modeling simulations. Site energy is expected to show more energy savings than source energy (Scofield, 2013). Office buildings are expected to have less opportunity for energy savings than higher intensity building types, such as hospitals, data centers, and laboratories. The data collection method – field observations or modeling simulations – are expected to uniquely affect the effect size. This particular issue is at the core of the debate on the inaccuracy of modeling simulations in the early phase of building energy program analysis, which is now verified by field observations (i.e., collecting actual energy data).

Table 5. Directional Statements.

Theory	Statement
Agency bias	Non-academic studies will report higher percentages of energy savings than academic studies.
Outdated baseline data	Studies that use CBECS as a baseline will report higher percentages of energy savings than studies that do not use CBECS as a baseline.
Unit of energy	Models based on site energy report higher percentages of energy savings than models based on source energy.
Building type	Models on office buildings report less percentages of energy savings than hospitals, data centers and labs.
Modeling error	Studies that use building modeling simulations will report higher change in energy use than studies that use field observations.

3.1.3_Meta-regression Design

An Ordinary Least Squares multivariate meta-regression is used to explain heterogeneity between effect sizes (Ringquist, 2013). The effect size is the unit of analysis and critical interest in a meta-regression. Effect sizes are "standardized measures of the relationship between the focal predictor and the dependent variable in original studies" (Ringquist, 2013, p. 18). In this case, the effect size is the percent change in energy use, measuring the relationship between the dependent variable in original studies, which is Energy Use Intensity (EUI) of buildings subject to the program intervention, and the focal predictor is each of the independent variables. EUI is a common unit used when researchers normalize different fuel uses into one unit of energy. Borrowing from Stanley and Jarrell (1989), the following model is used for the meta-regression:

$$bj = ß + \Sigma_{k=1}^{k} \sigma_k Zjk + ej \quad (j = 1,2,\dots L) \tag{3}$$

where bj is the estimate of ß of the jth study in a set of L studies, ß is the effect size, σ_k are the meta-regression coefficients, and Zjk are the meta-independent variables, including categorical variables for 1) type of journal, 2) data collection method, 3) policy or program, 4) building location, and 5) building use. As such, Zjk explains systematic variation across studies in the dataset represented as σ_k. Statistical analyses are generated using STATA Data Analysis and Statistical software, version 14.1.

Random, or r-based effect sizes are used when the effect size is different across models and studies, which are most common in public administration and policy studies rather than fixed effect sizes (Ringquist, 2013). R-based effect sizes can be standardized by applying weights (see discussion on weighting in Ankamah-Yeboah and Rehdanz, 2014, p.12). This study adopts the approach taken by Ankamah-Yeboah and Rehdanz (2014), which involves adding the sample size of buildings in each model as an explanatory variable in the regression. This approach was taken to retain the purity of percent change in energy use reported in each model of the original study, as reporting percent savings is a convention in energy efficiency program studies. One regression model was generated that applies weights based on the number of buildings in the model.

Some of the studies had different numbers of observations for subject and baseline buildings in the sample (e.g., Scofield, 2009). In these cases, I used the mean number of observations. In some studies, the researchers weighted Energy Use Intensity, such as by gross square footage in Oates and Sullivan (2011). In these cases, the weighted data was used to calculate the effect size because I assume that the research transformed raw data to improve accuracy of the model.

4_Results

While the paired t-test reports a 25% energy savings based on the mean EUI of subject and baseline buildings, the regression results report constants ranging from -22% to -15% change in energy use (Table 6). The constant represents the value of energy savings when all other variables are equal to zero. Regarding interpretation of a categorical predictor variable in a regression, the coefficient explains variation within the category. The variable given the value of 0 is the reference case.

Model 1 includes all observations, with a mix of percent change in energy use from site, source, and electric energy. Model 2 includes only observations whose percent change in energy use was calculated using site energy. Model 3, the most explanatory model ($R2=0.23$), weights the variables with the number of buildings in each model. The only statistically significant constant is found in Model 2, which determines an energy savings amount closest to the result of the paired t-test, 22% and 25%, respectively.

The following discussion refers to the directional statements conceptualized from the literature review (Table 8). As expected, models in non-academic studies reported higher amounts of energy savings than models in academic studies, supporting the theory of agency bias. Field measurements have a statistically significant negative relationship with percent change in energy

Table 6. Meta-regression Output, Percent Change in Energy Use as Effect Size.

	(1)	(2)	(3)
	Percent Change for All Observations	Percent Change, Site EUI	Weighted Percent Change, Site EUI
# Buildings in Model	-0.443*	-0.225	
	(-2.35)	(-1.94)	
Non-academic Study	-27.61**	-11.87*	-4.371
	(-3.27)	(-2.03)	(-1.30)
LEED	25.45	12.52	-0.205
	(1.87)	(1.49)	(-0.01)
Methods	-6.561	-19.15**	-41.98***
	(-0.58)	(-2.79)	(-5.12)
United States Location	10.27	5.377	9.793
	(0.58)	(0.52)	(0.57)
Office Building Type	1.768	4.584	2.654
	(0.21)	(0.83)	(0.74)
High Energy Use Building Type	2.125	17.23*	30.20**
	(0.18)	(2.73)	(3.32)
Recreation Building Type	-0.264	-1.921	6.279
	(-0.01)	(-0.10)	(0.20)
Constant	-21.55	-22.02*	-14.80
	(-1.31)	(-2.30)	(-1.45)
N (Observations)	168	130	130
R-squared	0.12	0.19	0.23
* p<0.05	** p<0.01	*** p<0.001	

t-statistics in parentheses

use. In this case, field measurements showed 7 to 43% more energy savings than modelling simulations. This could be caused by the outdated CBECS dataset for which actual energy data uses as a baseline to measure percent change in energy use. The high energy buildings use types (data centers, labs, healthcare) also show a high positive change in percentage of energy use, indicating percent change was positive rather than the desired negative change for these building types.

The EPA reports 2.4% energy savings from benchmarking (U.S. EPA, 2015b). Based on the meta-regression results, policy analysts can apply a positive adjustment for non-academic studies and studies that use field measurements rather than modelling simulations. A negative adjustment can be made for studies that pertain to high energy use building types. These adjustments may results in more accurate projections of energy impact from the program intervention.

5_Limitations

Originally this research sought to understand ways in which sustainability metrics are being linked to benchmarking policies. Because benchmarking as a policy option is so new, research on benchmarking policies is limited. Due to the limited benchmarking policy literature, I decided to discern if past commercial building energy analyses could inform research on policy impacts from benchmarking, particularly to avoid critiques similar to those that LEED received; that the policies do not achieve the intended energy savings. This is a critical issue in the energy efficiency field, as inability to more accurately project energy savings undermines policy design, its operationalization into measureable outcomes, and the technical capacity of the energy efficiency and green building field.

I had hoped to follow the conventional path of meta-regression analysis, where the researcher is interested in a focal predictor of the dependent variable. This approach requires the original studies to apply regression methodologies. Most of the studies that I reviewed on building energy analyses used difference of means as the statistical method. Consequently, I needed to use the program intervention as the focal predictor. I also wanted to include in the meta-regression a variable for occupant factors and number of LEED energy credits, but the data were not commonly included in the original studies in my sample selection.

Lastly, scholars from architectural and engineering disciplines may wish that this study had more information on the building-level dynamics between studies. For example, to what extent does the evolution of the LEED program explain variation in reported energy savings? And, why do different building types explain variation in percent change in energy use? While these questions were not intended for this study, the questions are worthy of exploration in future analyses within disciplines concerned with individual buildings or building types.

6_Conclusion

This research tests factors to explain variation across studies in an attempt to 1) inform the policy analyst's decisions to make adjustments to the percent change in energy use when projecting benchmarking policy impact, 2) to help explain to policymakers and environmental opposition groups why variation across studies exists, and 3) to expose the value of benchmark data to statisticians.

Application of this research for policy analysts. Communities need to know how much their portfolio of policies and programs has the potential to reduce communitywide energy use. Communities need this information for goal setting and measuring progress. With new benchmarking policies being adopted by local governments, curiosity about the effect that these policies will have on energy reduction is growing. We can rely on theories of information to anticipate changes in energy use, as theoretically buildings owners and managers will work to lower their energy costs as benchmarking data reveals opportunities for cost savings. Theories relating to information disclosure and market transformation support the role of benchmarks in the decision process to invest in energy efficiency. While benchmarking itself is simply an analytical tool, information has an effect on cognition and decision-making.

Application of this research for environmental advocates. There has been ongoing debate regarding the extent to which buildings policies and programs achieve desired energy savings (e.g. Oates and Sullivan, 2011; Scofield, 2009; Scofield, 2013). Some of the reasons for uncertainty include the questionable accuracy of computer-based modeling simulations (Stoppel and Leite, 2013), ambiguity in occupant behavior, outdated baseline data, and the unit of energy (site or source) that is analyzed. In addition to these technical issues, this research supports a political element to uncertainty in energy savings attributions, relying on agency bias theory. This information can help explain variation in original studies to policymakers and environmental opposition.

Application of this research for statisticians. Eco-labels (here, the program intervention) depend on benchmarks of baselines for comparison. Thus, this paper argues that attributions of energy savings are in part attributed to program interventions based on systematic variation in original studies, which can be improved by data availability through benchmarking policies. Indeed, benchmarking policies result in more publically available machine-readable buildings data. Increasing sample sizes and having a more representative sample of buildings will improve the accuracy and explanatory power of statistical models and computer simulations of building energy consumption. Consequently, benchmarking policies result in more informed choices for decision-makers to invest in energy efficiency based on better statistical models.

In conclusion, this research uses a meta-regression approach to discern the extent to which extant quantitative energy efficiency literature has systematic biases that effect energy savings attributions. Arguably, the study of program effectiveness for energy use in buildings is at a historical point because of new benchmarking policies being adopted by cities throughout the United States making more data available, which can be used to validate modeling simulations. Timely with this historical shift in building energy policy analysis, it is important to reflect on **current** knowledge about changes in energy use resulting from building policies and programs that have been active for the previous decades. Further, analysts must work to determine how much change in energy use can be achieved from benchmarking policies, as benchmarking itself, like energy audits, do not actually save energy (or do they?).

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Abstract

Cities are becoming more complex and smart not only in terms of civil engineering infrastructures, ICT based systems, energy efficient buildings, inteligent traffic systems but also in their socioeconomic systems. ICT technology enables to monitor, understand and analyse cities and neighbourhoods in multiple ways. Already, there are many performance indicators and data collection procedures to assess smart city solutions and projects. Only few focus on smart neighbourhoods and the socio-economic opportunities of smart urban developments.

This paper provides a strategic framework how smartness of neighbourhood scale urban developments could be assessed. The method proposes three levels to be considered. The first level evaluates the sustainability of the neighbourhood in traditional terms of the environmental, social and economic aspects. The second level addresses how the ICT systems enable urban development to become more sustainable. The third level adds the level of assessment of the citizens: how do they perceive the sustainable and ICT dimension of the neighbourhood. This new method of addressing the smart performance of neighbourhood can help decision-makers in selecting and clarifying the areas which need improvement and enables the development to constantly adapt to emerging socio-economic challenges.

SMART AND SUSTAINABLE NEIGHBOURHOOD ASSESSMENT:

investigating the human perspective of smart neighbourhoods

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1_Introduction

1.1_Importance of the topic

Since the first mention of the smart city in the 1990's, the vision has become popular not only among city leaders and citizens but among researchers. However, it is difficult to identify shared definitions and common trends at a global scale (Khansari et al, 2014), several study made an attempt to define the main dimensions and common characteristics of smart city concepts (Albino et al 2015; Neirotti et al 2014) and differentiate the meaning 'smart' from other terms used interchangeably to describe a liveable city (de Jong et al 2015). Based on previous studies it can be assumed that the optimization of available and new resources is an important part of smart urban development (Lazaroiu and Roscia 2012). However, it is clear that the limitations of hard infrastructure oriented strategies are now recognized and the concept of a smart city evolved to a socially inclusive direction (Mattoni et al 2015). It was revealed by many that technology in itself is not enough, as it does not imply that people will behave and act smart (Anthopoulos and Tougountzoglou 2012; Angelidou 2014). At the same time networked infrastructure and ICT technology that revises political efficiency and sustainable social/cultural development is often mentioned as a key element of being smart (Manville et al 2014) Social and human capital and interconnection between people and the city, as an enabler to creativity and innovation are also declared fundamental (Schaffers et al, 2011). Citizens have a key role in smart cities, based on the concept of Living Labs: they are not only informed about their activities and their neighborhoods, but they became key player of shaping their cities (Cosgrave et al, 2013).

While the definition of smart cities is getting clearer, in practice city leaders are still strain to quantify the benefits that novel ICT can generate (Cosgrave et al, 2013). Although the social aspect gains emphasized attention in most smart city concepts, this aspect is the most difficult to measure (de Jong et al 2015). Moreover, assessment tools to address the smartness of any neighbourhood is still missing, despite of the fact that several neighbourhood sustainability assessment tools have been invented in the past decade to help the creation of sustainable, well-performing, liveable communities.

1.2_Research objectives

This paper explores whether an initiation of neighbourhood scale 'smart' assessment is useful to realize smart and sustainable urban development projects which can be scaled up to a city scale later on. The study also establishes a framework for such an assessment. In order to achieve this in the current research we assume that sustainability is a key to liveable and creative cities. We also suppose that data can improve the sustainable quality of neighbourhood developments from the better design of the building to the improved quality of life, as it can lead to behavioural change. Based on that, the hypothesis of the study is that neighbourhood scale assessment has the potential to quantify the benefits of smart initiatives of neighbourhoods both in terms of measuring the effects of implementing ICT technology and also, evaluating how citizens change their interactions and behaviour as an effect of advanced access to information.

1.3_Methodology

Understanding the potential value of neighbourhood scale smart assessments requires a comprehension of constraints in city scale smart city projects and the replicability limitation of any smart initiative. It is also necessary to learn how sustainability aspects are integrated in realized and ongoing smart city projects and vice versa: how sustainable urban development projects use smart technology. Therefore, we have undertaken a literature review of the scalability and sustainability prospects in smart city concepts. We have also studied the presence of digital layer among smart city indicators in order to identify whether and how ICT can be used to measure improvements in the sustainability level of the project. As citizens play an active role in smart initiatives an analysis has been performed focusing on how people make their choices, how changes in behavioural outcomes can be measured.
On the basis of the research we formulated a framework for an assessment which considers sustainability, the effect of ICT use, participation and behavioural change on the same page.

2_Scale of smart initiatives

Studies often define that smart city initiatives have the unintended potential to grow social disparities among the population by digitally dividing the people (Chourabi et al 2012; Angelidou 2014). It means increased inequality and not equal accessibility to ICT technology. In other terms smart city has the possibility to fail to provide accessibility to different smart assets for all citizens, e.g. in Rio de Janiero (Angelidou 2014). It implies that the 'smartness' of a city cannot be assessed based on certain smart city projects implemented in the city as they do not necessarily affect the whole city. Moreover, large size has potential to have more barriers to smart cities, e.g. longer installation times for smart technologies (Neirotti et al 2014).

Manville et al (2014) have performed an analysis of existing smart city projects in Europe. They stated that smart city projects differ greatly in their size, scalability and maturity level. This heterogeneity makes the comparison of smart city project difficult; moreover, their relative immaturity renders the assessment of the success factor really hard at city level. For the purpose of Manville's study to identify how auspicious any given project is: different smart initiatives were grouped in five main categories. These were the following: Smart City Neighbourhood Units; Testbed Micro Infrastructures; Intelligent Traffic Systems; Resource Management Systems and Participation Platforms. The research showed that Intelligent Traffic Systems; Participation Platforms, Testbed Microinfrstuctures are likely to address certain dimensions of a smart city; Smart Neighborhoods could cover more evenly the smart dimensions, namely: Smart Environment, Smart Mobility, Smart Economy, Smart People, Smart Living, the only dimension which has not been addressed is Smart Governance. Smart Neighbourhoods have the capability to identify 'good practice', on the other hand, the solution implemented in Smart Neighbourhoods is likely to be site-specific, hence with limited replicability potential. The scaling up potential of testbed micro infrastructures and intelligent traffic systems are the highest. Testbed Micro Infrastructures are demonstration and testing pilots in real-life context used to understand and study how to integrate, manage and monitor the behaviour of implemented technology, so as connect as many things as possible, in the sense of the 'Internet of Things' (Manville et al, 2014).

Local context is really important in case of smart initiatives: the success of smart city strategies depends greatly on the local socio-economic and cultural background (Neirotti et al 2014). Moreover, most research on low-carbon communities focus on geographically local communities which have place-based identity, shared history, shared infrastructure, and political and administrative power (Heiskanen et al 2010). In that sense neighbourhood level communities have place-based identity, common history and infrastructure and they are embedded in a given political and administrative context of their city. In order to transition to low carbon communities a change is required in social practices, norms and values. As a range of technological solutions are not accommodated in the social context, they have not resulted in the expected energy efficiency gains. Local communities are more likely to approach change towards a low carbon life, as their approach is suited to local contexts, therefore can address more appropriately change in the social practice (Moloney et al 2010). According to Gardner and Stern (1996), one of instruments to change behaviour in relation to environmental problems is community management of environmental resources. It is also pointed out by Mancha and Yoder (2015) that people's intended behaviours are strongly influenced by perceived social pressures. Therefore, strategies aiming to increase awareness of green social norms could more efficiently shape behaviour. Nonetheless, urban designers currently have no comprehensive measurement tool to quantify the interconnections that take place at neighbourhood developments and procedures to have feedback during the design process to see the consequences of their decisions (Frenchman et al 2011)

3_Layers of smartness based on current literature

3.1_Sustainability prospects in smart city concepts

According to de Yong's comprehensive bibliometric analysis (2015) smart city concepts becoming important drivers of urban sustainability and regeneration initiatives. The assurance of social and economic aspects of sustainability – which originates in the Smart Growth Movement, in the late 1990s – is often referred as the key role of smart cities. Connection between environmental and ecological sustainability is weaker, most definitions of smart city do not concern ecological sustainability (Kramers et al 2014). In the same study, Kramer et al suggested the use of the terms: "smart sustainable cities", referring to smart cities that promote environmental sustainability as well. We use the same terms in this paper considering smart urban developments that address all three pillars of sustainability.

However Smart City has been more about liveable, creative, digital and knowledge-based cities (Marsal-Llacuna et al, 2015), the pursuit of sustainability – not only in terms of social and economic sustainability, but in terms of environmental sustainability – is getting to be an important element of smart city definitions (Barrionuevo et al. 2012; Bakici et al. 2012; Ballas 2013, Albino et al 2015). The examination of the analyzed Smart Neighbourhoods in the study of *Mapping Smart Cities in the EU* reveals that environmental aspects are well represented in them. Reduced energy consumption, the integration of smart meters and grids, the use of renewable energy, effective water and waste management systems and efficient public transport system frequently appear in the projects. Besides the environmental objectives, the projects emphasize Smart Living, the dimension to enhancing residents' quality of life (Manville et al 2014). In MIT's study of clean energy communities also reveals social aspects of sustainability: it states that successful clean energy projects include feedback mechanisms or other programs to commit citizens in their ambition of energy saving. Moreover, they support the formation of strong communities where residents are more likely to modify their energy behaviour (Frenchman and Zegras, 2012).

3.2_ICT as an enabler to smart sustainable cities

Smart city concepts are often attached with the idea of a digital platform and the use of ICT (Bakici et al., 2012; Jucevicius et al., 2014, Caragliu et al., 2009) which serves as digital nervous system that obtains data from heterogeneous sources (Neirotti et al, 2014). Jucevicius et al. (2014) has examined the impact of various digital systems on the 'smartness' of the city. They established a set of indicators strongly related to digital dimension and conducted a research how well these indicators are represented in various studies. It has been affirmed that digitalism does not dominate in any of the main features among smart city categories, but it is important to all of them and underlies all characteristics. In other studies, the opportunities of using ICT as an enabler to reduce energy use in cities has been analyzed (Kramers et al 2014; GeSI, 2008). ICT has capability to help forming more sustainable cities through *dematerialization* (conversion of physical products to digital ones), *demobilization* (transportation via the telecoms network instead of being physically transportation), *mass customization* (use of less resource use because of the adaptation and personalization potential of ICT), *intelligent operation* (resource-efficient operation) and *soft transformation* (transform because of new opportunities) (Mitchell 2000, Kramers et al 2014). The study of Kramers et al (2014) differentiated two types of ICT solutions: the ones with a direct effect on energy consumption and the ones which are ICT enabled and have indirect effect. The research states that energy reduction opportunity has not yet been realized to its greatest extent (Kramers et al 2014), however the influence of ICT by enabling energy efficiencies in other sectors is predicted to deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020 (GeSI, 2008).

ICT enabled smart initiatives are strongly associated with the use of Internet of Things (IoT). Internet of things is integration of various technology and communications solutions. The IoT is the concept of a global, network infrastructure where physical and virtual "things" (devices, sensors, smart objects, etc.) communicate and share information among each other dynamically (Silva and Maló, 2014). Among others it means the *Identification and tracking technologies, wired and wireless sensor and actuator networks, enhanced communication protocols and distributed intelligence for smart objects* (Atzori et al 2010). Potentials offered by the IoT make the development of a huge number of applications possible in domains such as *Transportation and logistics, Monitoring of industrial plants, Healthcare, Emergency, Smart environment (home, office, plant) domain, Personal and social domain*. IoT integrates several enabling technologies, such as RFID systems, wireless sensor networks, Smart meters, GPS terminals etc. (Atzori et al 2010, Borgia, 2014).

3.3_Examination of citizens, behavioural aspects

The social learning theory of Bandura (1977) finds out that learning is a cognitive process and it changes through the social context. Most behaviour lead to consequences which will impact the future behaviour: either maintaining or changing it (Khansari et al, 2014). Based on the idea of Coe et al (2001) smart city is the place, where behavioural change can occur: it is *A city whose community has learned to learn, adapt and innovate*. Soft infrastructure and people-oriented smart city concepts are strongly based on these theories: the promise of a smart city is – among others – that it can foster behavioural change towards a more sustainable lifestyle (Angelidou, 2014, ARUP 1999). The service innovation of smart city allows provides real-time information on the performance of systems and resource consumption, additionally insight into citizens' behaviour in order to recognize, study and act on those patterns (Frenchman et al. 2011). This does not only mean a highly instrumented top-down method: such real-time engagement can change people's energy behaviour (Darby, 2006), feedback data allows citizens to alter their actions accordingly while making better use of the resources (Khansari et al, 2014). The investment in human and social capital is essential to be smart and sustain the economic growth and a high quality of life (Caragliu et al. 2009). Smart Neighbourhoods strongly rely on citizens; they are the ones who can enliven the smart technology. The commitment of the stakeholders is essential, without them, the data available can't shape a smart city. Therefore, citizens should be engaged through a participative environment to contribute to and create smart neighbourhoods (Manville et al. 2014).

The idea of Internet of Things has a high impact on several aspects of every-day-life and the behaviour of potential users (Atzori et al. 2010). Moreover, on the basis of *Information Marketplaces* concept: city can be used as a real-world testing ground for new ideas and technologies where users are transforming from passive recipients of ideas, services and solutions to active generators and creators of the their smart city. The value chain perspective is necessary to obtain full value from their ICT investments, where real-time data inputs (e.g. number of passengers, journey time etc.) serve as a base for gathering information components (e.g. usage patterns of public transport system) which then generate information products (e.g. feedback to improve public transport). *Living Lab* has the infrastructure to provide a vast amount of data as inputs into this new value chain (Cosgrave et al, 2013). The development of a digital platform is important in order to have a smart social system, however many social systems can be smart without necessarily basing their activities on Information and Communication Technologies (Jucevičius et al. 2014).

Based on the above it is evident that citizens are inevitable to create positive impact in the smart urban environment and make data to be a value. However, it is addressed by only a few, how the evidence of this value should be measured. Priano and Guerra (2014) defined an N-dimensional framework where each dimension of the smart city can be evaluated independently. Amongst others they stated that even though cities implement smart solutions and services, the actual level of smartness is valued by the residents, and measures that evaluate smartness should be representative of the entire city. Therefore, they included the assessment of the citizens in the overall framework which is a complementary part of the evaluation. This is in line with the estimation that only 5% of the available digital information is currently being used (Marsal-Llacuna et al. 2015). Carli et al (2013) also outlined a human centric framework to access smart cities. Besides the fact that they categorize indicators based on the degree of objectivity, they state that the level of technological advancement of data extraction is also an important characteristic to evaluate an indicator. For example, indicators with a high degree of subjectivity can be derived either from traditional repositories such as surveys and questionnaires, or extracted from innovative tools based on data sensing and mining of the physical and social infrastructure, e.g. complex analyzes of user generated data such as web based reviews, ratings and recommendations.

4_Results

Neighbourhood scale smart initiatives could describe more extensively the attributes of the smart city, with less potential for scaling up. However, there are smart city project types with higher replicability potential. One of Test-bed microinfrastructures has to capability to be combined with Smart neighbourhoods, as they are not place-based. Test-bed microinfrastructures strongly emphasize the use of Internet of Things (IoT). The implementation of IoT at neighbourhood scale assessment could have the capability to measure the effects of implementing a given information technology and give feedback on citizens behaviour, and vice versa provides information to the user to enable their behaviour change. Besides the fact that neighbourhood scale developments have the potential to form communities, as these developments are greatly embodied in the local socio-economic context; from an energy consumption viewpoint: they can also reveal interrelationships of urban form and the behavioural component of neighbourhood energy consumption. Links between multiple buildings and citizens, plus synergies generated as a result of interaction in the urban context, can be introduced. Examining the analyzed Smart Neighbourhood projects in the study of Manville et al (2014) (London suburb of Hackbridge, UK; Hafencity in Hamburg, Germany; Nordhavn in Copenhagen, Denmark; Stockholm Royal Seaport, Sweden; Oulu Arctic City; Finland), revealed that none of the them had a developed smart assessment scheme to address the smartness of the development. It is not evaluated whether ICT is used to measure improvements in the sustainability level of the project and whether the change of behaviour or feedback on the implementation of any measure is addressed. However, they are just in the planning or development stage.

The literature review revealed that sustainability is a comprehensive base for smart city initiatives. Social and economic sustainability is more featured in smart city projects in general. At the same time, the need to acknowledge the environmental pillar of sustainability is remarked in addition in neighbourhood scale smart city projects, the environmental aspects are more significant. Therefore, the realization of sustainability as a whole should be assessed when the smartness of any neighbourhood is examined and it should provide a base for any smart neighbourhood evaluation. Therefore, if a neighbourhood aims to be smart, measures taken to reach that goal should be based on the principles of sustainability. Based on different smart city definitions it turned out that smart cities strongly rest on networked infrastructure and ICT. Smart city projects which have strong sustainability ambitions should seek to understand how to utilize best potentials offered by ICT and how to measure its actual impact, which is not necessarily positive (rebound effect). For the successful delivery of ICT investments, it is necessary utilize them to the fullest and create value from the data set they can provide. *Living Lab* has the supply network to support the understanding of value beyond the optimisation of systems. Based on that, smart neighbourhoods should have ICT based tools and procedures to realize smartness. The current study also shows the relevance of citizens in successful smart city initiatives. It also emphasizes that interconnection between people and the city is significant.

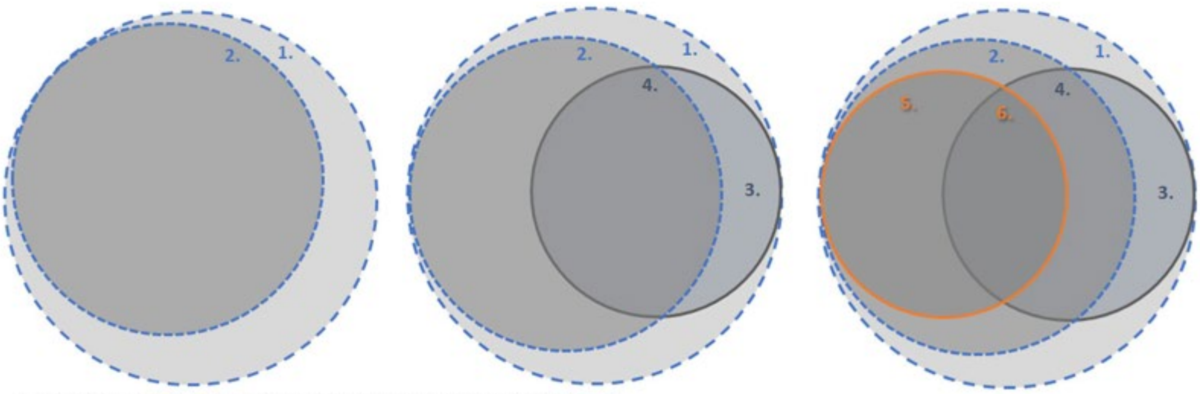
Figure 1. *Proposed layers of smart neighbourhoods based on the literature review*

1. Potential measures to achieve a smart sustainable neighborhood
2. Realized measures to achieve smart sustainable neighborhood
3. Potential ICT measures (direct and ICT enabled indirect)
4. Realized ICT measures
5. Measures that enable participation, behaviour change
6. Realized ICT measures that enable partecipation, behaviour change

Accordingly, smart neighbourhoods should have a mechanism that enables participation and behaviour change. These instruments can be partially ICT-based, as Information and Communications Technologies are implemented either to reach higher efficiency in the hard infrastructure or optimize the soft infrastructure of the city.

5_Proposed layers of smart neighbourhoods based on the literature review

With reference to the above mentioned the current study proposes that smart sustainable neighbourhoods have the following layers: they are established on measures implemented to gain sustainability (Figure 1, set 1 and 2), part of these measures is ICT based, or ICT enabled tools (Figure 1, set 3 and 4). Behaviour change and the inclusion of citizens form the third layer of smart sustainable neighbourhoods (Figure 1, set 5 and 6). Potential measure is differentiated from the realized ones. In that sense, smart neighbourhoods are the ones represented under set 4, 5 and 6. They have to be based on sustainability, and which can be gained with the implementation of ICT or it can lead to behavioural change and higher involvement of the citizens.



6_Framework for Smart Sustainable Neighbourhood Assessment

The determination of smart qualities of urban developments in order to define a framework for smart sustainable neighbourhood assessment has been a critical challenge. The above mentioned layers provide an outline for such methodological framework. It also has been showed that there is a gap in the plateau of smart assessment schemes, as they focus on city scale; while neighbourhood assessments concentrate on sustainability aspects. Furthermore, technology innovation must have a clear evidence of the value of its application: the effects of implementing ICT and ICT enabled technology should be measured. Even though social aspects are an essential part of most smart city definition, there is no framework to evaluate how citizens change their interactions and behaviour, as a result of advanced access to information and implemented sustainability measure. Based on that, there is a potential in developing a Smart Neighbourhood Assessment scheme which could have the possibility to describe smartness gained by all of the citizens in the analyzed neighbourhood, and it could have the capability to compare different smart neighbourhoods and builds up a model with soft and hard infrastructure.

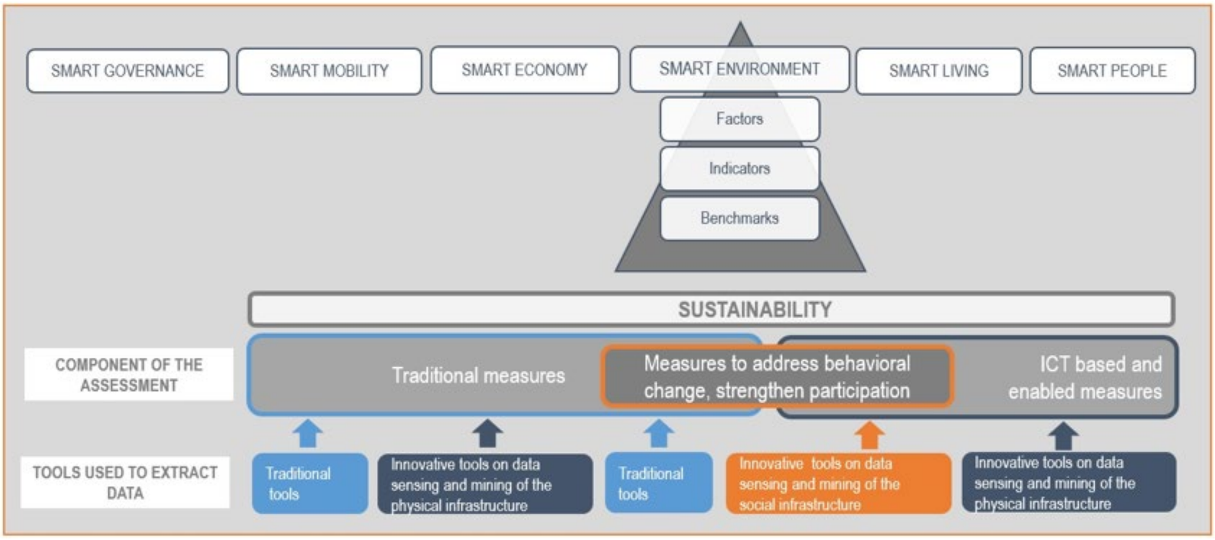


Figure 2. Methodological framework

The methodological framework (Figure 2) that we propose reflects the different layers of being smart defined above. It uses the certain aspects from various studies: Priano and Guerra 2014; Carli et al 2013; Giffinger et al 2007.
The first level of the assessment is the evaluation how sustainable the neighbourhood is. Sustainability can be gained by several ways. One option is implementing traditional tools, such as passive design measures and energy efficient mechanical systems to gain environmental sustainability or applying regulations that provide equal rights to citizens in order to assure social sustainability etc. The first layer of the assessment represents these measures. The impact of traditional assets can be evaluated either with traditional tools (e.g. statistical data describing life expectancy) or innovative tools on data sensing and mining of the physical infrastructure (e.g. data extracted from smart grids). The utilization of Information and Communication Technology can also contribute to sustainability e.g. smart metering can help resource efficiency or internet can provide access to data.
The second layer represents ICT based tools and protocols. This layer can describe both ICT measures in itself or technologies that are enabled with ICT such as car-sharing. Therefore, the assessment of this layer is based on innovative tool on data sensing and mining of the physical infrastructure as all measures can be evaluated with ICT.
The assessment of the people is the third layer; it reflects the human perception of actions taken. It measures the change in citizens' behaviour to a more sustainable one, so as the involvement of the people in the design, operation of the neighbourhood. Data can be extracted by traditional tools, such as questionnaire about occupant behaviour, or data can be gathered with the help of ICT, for example data mining from social media platforms. The framework preserves the classical dimensions of smart cities (Smart Living, Smart People, Smart Environment, Smart Government, Smart Economy, and Smart Mobility). These characteristic can be determined by a number of factors. Furthermore, each factor is described by a number of indicators. Indicators can evaluate by benchmarks. The different measures are used to fulfil the benchmarks and different tools can be used to measure the performance of different measures.

7_Conclusions

The concept of a smart city has been named as both a challenge and an opportunity for cities (ARUP, 1999). This study emphasizes that in case of a neighbourhood development a transparent and uniform methodology should be developed to address the smart dimensions of a neighbourhood and help to explore these challenges and opportunities. In the paper a framework has been presented for assessing smartness of neighbourhood developments on a theoretical approach. This framework brings together a large number of previous studies into one methodology, including researches approached to define smart cities at conceptual level and smart city ranking and evaluating schemes. Moreover, the study is enforced with literature review of how sustainability, ICT and behavioural aspects are embedded in smart city initiatives. This methodological framework addresses the smart qualities that current cities should have: it should satisfy sustainable development, include ICT in the life-cycle of a development and facilitate awareness driven change in the behaviours of citizens. With the framework strategies can supported aiming to create sustainable neighbourhoods using up-to-date ICT technology and concerning citizens' quality of life. In addition, potential solutions and projects can be compared to decide which ones offer the best results for the neighbourhood in line with the above mentioned qualities.
In the future specific factors, indicators, benchmarks, measures and evaluation tools of the methodology have to be fully investigated. Subsequently, it has to be considered that different cities have different needs and face unique challenges. Therefore, the proportion of traditional and ICT-based measure can be different, and even the solutions to evaluate the measures can be specific. Future work is planned to perform experiments on these ideas by implementing the framework on existing territorial contexts and on different state of the integrated design process.

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Sustainable Urban Districts Retrofitting

BIPV SOLUTIONS IN RESIDENTIAL RENOVATIONS TOWARDS NEARLY ZERO ENERGY DISTRICTS

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Abstract

The current building stock is formed by about 160 million buildings in EU-25 that represent about 40% of the energy consumption and 36% of the EU's total CO_2 emissions. The construction of new buildings represents only 1-1.5% of the building stock so the focus needs to be put on renovation of existing buildings in order to achieve substantial impact in terms of energy saving and GHG reduction.
In this sense, the propose of R2CITIES project, funded by the European Commission through its Seventh Framework Programme, is to develop and demonstrate replicable strategies for designing, constructing and managing large scale district renovation projects for achieving nearly zero energy cities. These results will open the way for new refurbishments on a European scale within the framework of new urban energy planning strategies.
One of the innovations within R2CITIES is the implementation of Building Integrated Photovoltaic Solutions (BIPV) for districts retrofitting, used for replacing conventional building materials with the advantage of generating electricity providing at the same time passive benefits as heat insulation, daylight entrance or acoustic comfort.
Onyx Solar has studied the behaviour of the PV ventilated façade in three European demonstration sites located in Kartal (Turkey), Genoa (Italy) and Valladolid (Spain). In addition, it is expected to obtain an innovative urban mobility concept related to the renovation at district level focused on the development of a PV Parking-Lot for public lighting and charge of electric vehicles. This paper is focused on explaining the main BIPV solutions and its application for R2CITIES.

1_Introduction

The energy consumption existing model based on fossil fuels is completely unsustainable. Not only because the energy increasing demand is reducing the estimated reserves, but also for the clear evidences of environmental affectation on account of their use (pollutants global warming, etc.). The most efficient alternative energetic solution, the nuclear generation, supposes a radioactive pollution risk that many citizens are not willing to assume.
Specifically, as the result of the energy waste, 40% of greenhouse gas emissions and 38% of global energy demand, come from buildings. This puts us in a current case mix of climate change with obvious consequences, and where buildings located in large urban areas have a critical role.
Thus, the commitment of different governments and supranational organizations, establish pre-agreements to promote renewable clean energies and guaranty on a long term basis the sustainability of earth resources and thus promoting the concept of post-carbon energy cities.
Within this framework, the new European Directive on Energy Saving in Buildings (European Energy Performance of Buildings Directive-EPBD) was published, setting the objective of reducing the annual building energy demand to a critical value of 70 kWh/m^2 by the year 2020.

Similarly, the 2020 Energy Plan "A strategy for competitive, sustainable and secure energy", published by the European Commission, established the following key objectives:

- 20% cut in Europe's annual primary energy consumption by 2020.
- Reducing overall greenhouse gas emissions by 20% compared to 1990 levels.
- Achieving the 20% share for renewable energy sources (RES) in the gross final energy consumption.

On the other hand, governments are analysing the possibility of promoting the photovoltaic energy integration in buildings. This solution provides immediate energetic savings in the actual net electric consumption and economic feasibility on medium-long term basis; it should be taken into account that photovoltaic systems suppose an additional saving cost in transportation and energy distribution, one of the main limitations of the access to effective energy sources.

2_High-value photovoltaic solutions for smart cities

2.1_Building Integrated Photovoltaic Solutions

Essentially, Building Integrated Photovoltaics (BIPV) refers to photovoltaic cells and modules which can be integrated into the building envelope as part of the building structure, and therefore can replace conventional building materials, rather than being installed afterwards. Thus, BIPV solar modules have the role of a building element in addition to the function of producing electricity. The wide variety and the different characteristics of the available BIPV products make possible the replacement of many building components, mainly in façades and roofs. BIPV offers the possibility of adopting many different designs in terms of patterns, shapes, colours and light transmission parameters so it supposes total flexibility in architecture design adding new elements in which PV can be integrated in an affordable and cost-effective manner, contributing to create more sustainable cities capable of not depending on fuel and carbon resources.

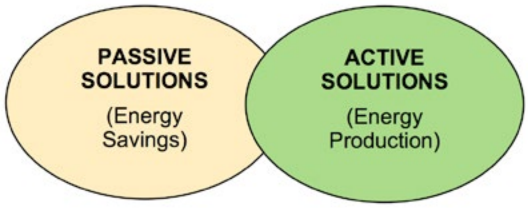


Figure 1. Multifunctional concept of BIPV solutions. Source: Onyx Solar.

The building envelope guarantees a border between the inner building environment and the outer climate. Moreover, the envelope provides a waterproofing layer to the building. Thus, façades and roofs take over regulation and control functions in relation to the daylight, ventilation, energy, etc.

When BIPV modules are planned to be integrated in the building envelope, they should be considered during the design phase in order to optimize passive and active properties.

Additionally, there are other BIPV features that must be considered. Some of them are:

- Acoustic protection.
- Thermal insulation.
- Visual refraction of the cover.
- Safety glasses.
- Waterproofing.
- Sun protection.

2.2_Type of BIPV Integrations

Together with the evolvement of the integration of modules in the architecture, the new BIPV products are capable of fully replacing some building components: construction elements of the building envelope (roofing, façade cladding and glazing surfaces) and architectural elements (porches, balconies or canopies). The main examples of BIPV integration are summarized in the following pages.

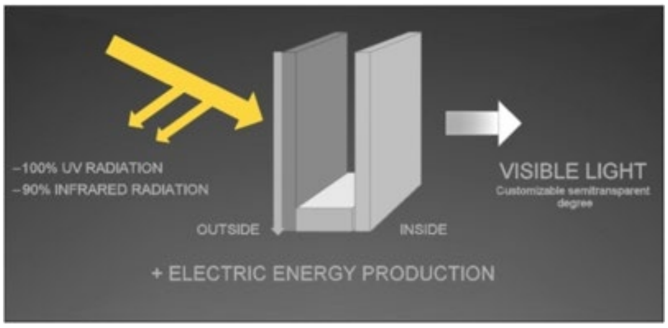
2.2.1_Photovoltaic Skylights and Curtain Walls

Figure 2. Skylight PV Integration. San Antón Market, Madrid (Spain). Source: Onyx Solar.

Photovoltaic skylights and curtain walls ensure optimization of the energy generation providing at the same time bioclimatic properties and thermal comfort inside the building, as most of the ultraviolet and infrared rays are absorbed by a silicon-based material that acts as a sunscreen. In addition, it is possible to design and manufacture double and triple glazing where the outer glass is photovoltaic and the passage of natural light is allowed. Moreover, low emissivity (low-e) layers can be added in double and triple glazing in order to avoid energy losses, reducing the cooling needs and generating an improved inner comfort.

Traditional glass used in skylights and curtain walls can be replaced by photovoltaic glass, optimizing the envelope performance and allowing on-site energy generation. In this type of integrations, photovoltaic glass should have a transparency degree in order to permit the entrance of natural light into the building. The semi-transparency is achieved by a laser process on fully-opaque thin film modules. For projects requiring specific conditions as thermal insulation, insulated solar glass units can be considered, in order to comply with building specifications.

Figure 3. PV Curtain Wall scheme and real integration in Guadalhorce Headquarters, Málaga (Spain). Source: Onyx Solar.



2.2.2_Photovoltaic Ventilated Façade – Double Skin

A PV ventilated façade is a multi-layered building envelope, consisting of an outer layer made of photovoltaic glass that is mechanically connected to the inner layer using a substructure and a ventilated air gap which contains the thermal insulation. The air cavity allows controllable ventilation of the system. The outer layer can be installed a certain time after the building completion, as an energy efficient measure. The ventilated air chamber and the application of insulating material increase the acoustic absorption and reduce the amount of heat absorbed by buildings. In the air gap, the density difference between hot and cold air creates a natural air flow that heats up through a chimney effect. That is a natural ventilation system that helps to eliminate heat and moisture, increasing interior comfort.

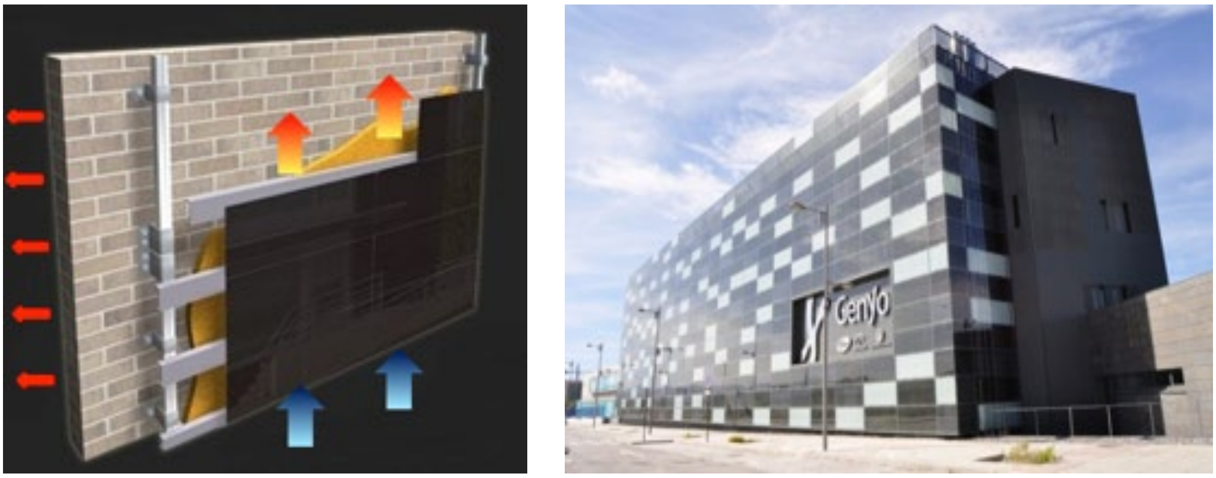


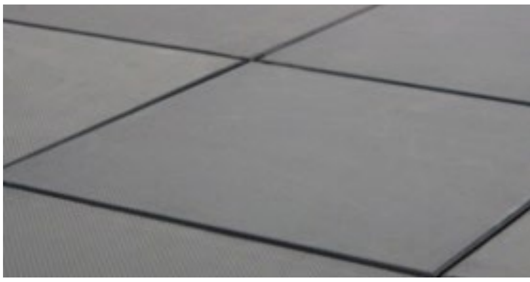
Figure 4. PV Ventilated façade scheme and double Skin PV real integration in Genyo Building, Granada (Spain). Source: Onyx Solar.

The outer PV layer allows generating solar energy for its use to cover the building demand. PV technology is integrated in an aesthetic manner being a perfect choice for replacing conventional materials such as regular glass, ceramic or stones with a great final result. Amorphous silicon technology typically used for the PV layer can be treated to obtain a transparency degree so when it is covering windows natural light can pass through the building.
On the other hand, this solution can lead to savings among 25-40% of the total building energy consumption. Depending on the façade orientation, the building location and the photovoltaic technology used, the electricity generated by a single square meter of the PV ventilated façade can vary between 40-200 kWh per year.

2.2.3_Photovoltaic Walkable Floor

This innovative system consists on the installation of photovoltaic tiles, triple laminated glazing units based on a-Si solar cells, to be integrated as a walkable floor. The PV tiles comply with the anti-slip regulation and supports 400 kg in point load test.
As previous solutions explained, the PV walkable floor combines passive elements (avoiding CO_2 emissions) with active elements (for power generation), significantly reducing the environmental impact of the building.

Figure 5. Photovoltaic Walkable Floor. George Washington University, Virginia (USA). Source: Onyx Solar.



2.2.4_Photovoltaic Canopies and Parking Lots

A photovoltaic canopy is a constructive solution used in urban environment that combines power generation with solar protection properties against adverse weather conditions. The energy generated by the PV system can supply nearby buildings or can be injected into the grid, achieving a significant economic benefit.
Some important factors that must be taken into account when designing the canopy are the orientation, the minimum slope, dimensions or wind and snow loads.
With respect to PV Parking lots it is possible to add new functionalities apart from the traditional use for protecting vehicles against weather conditions. In this case, the solution consists of a parking structure where the PV installation guarantees on-site power generation that can be used to satisfy different needs such as street LED lighting or supplying the batteries of an electric car.

Figure 6. Photovoltaic Canopy. BART Station, San Francisco (EEUU). Source: Onyx Solar.

The aesthetic sense of this solution seeks maximum energy production and maximum protection from adverse weather conditions, such as rain and wind. For this reason, a locking structure integrated in the module could be proposed, formed by a mobile timber panel over the outer face of the photovoltaic panels. The cover is designed with a minimum slope, being capable of easily evacuate the rainwater and at the same time, versatile in any orientation, thus location losses never exceed 8%.

Figure 7. Photovoltaic Parking Lot Design and real project in Lamezia Terme, Italy. Source: Onyx Solar.

3_The role of Onyx Solar in R2CITES European project

3.1_R2CITIES Project Objectives

The current building stock is formed by about 160 million buildings in EU-25 that represent about 40% of the energy consumption and about 36% of the EU's total CO_2 emissions. The construction of new buildings represents between 1-1.5% of the building stock while the removed buildings represent about 0.2-0.5%. Assuming that this trend will continue in the period ahead, the focus needs to be put on renovation of existing buildings in order to achieve substantial impact in terms of energy saving and GHG reduction. Taking into account that the number of refurbishments accounts roughly 2% of the housing stock per year, we can estimate that around one million dwellings are refurbished every year.

The purpose of the R2CITIES project is to develop and demonstrate replicable strategies for designing, constructing and managing large scale district renovation projects for achieving nearly zero energy cities. These results will open the way for new refurbishments on a European scale within the framework of new urban energy planning strategies. R2CITIES aims to develop and demonstrate an open and easily replicable strategy for designing, constructing, and managing large scale district renovation projects for achieving nearly zero energy cities. This project is coordinated by the research centre CARTIF and has received funding from the European Union's Seventh Programme for research, technological development and demonstration.

Three demo sites will be addressed for demonstrating the framework and associated impacts by developing real cases going beyond current market standards but ensuring the replicability of the concepts deployed. This ambitious renovation plan of three residential districts, will involve more than 57,000 m^2, more than 850 dwellings and more than 1500 users, with a potential of energy consumption reduction close to 60%.

3.2_PV Parking Lot: Towards Smarter Urban Mobility

Onyx Solar, as a partner of R2CITIES project, has developed a study of PV solutions for the improvement of the energy performance of buildings at district level. In this context, PV solutions must be analysed not only for their integration in building envelopes, but also for their contributions to the district. This paper will focus on the description of the PV Parking Lot proposed for the demo site in Valladolid, as part of R2CITIES project.

Regarding BIPV integration, it is possible to study its involvement at district level based on two different concepts: energy management systems and urban mobility. A new concept of energy management system must be evaluated, allowing that the energy produced by the BIPV systems located in selected buildings, would be distributed and consumed by all the district inhabitants.

European cities increasingly face problems caused by transport and traffic. The question of how to enhance mobility while reducing CO_2 emissions and pollution is a common challenge to all major cities in Europe. The implementation of energy efficiency technologies, as photovoltaic canopies or photovoltaic parking lots, is a recommended solution to improve the quality of urban mobility sector.

3.3_Introduction to the Electrical Vehicle Market in Spain

In the EU, transport sector represents a final energy consumption of 377 million tons of equivalent oil (Mtoe), which accounts a 33% of total final energy consumption. In Spain, with a consumption of 42 Mtoe, this percentage is as high as 43%, with the added effect of an exclusive dependence on oil, which comes from a few countries with enormous geopolitical instability. In particular, the car consumes almost the 30% of the total oil demand. Currently, there are 900 million vehicles in circulation, of which about 30 million are registered in Spain and nearly three quarters correspond to cars.

Now more than ever, the respect to the environment and energy efficiency are being considered. In this respect, the electrification of transport seems to be the response to the need for greater energy efficiency and lower emissions. It is important to identify how the electrification of transport can contribute to achieving the objectives of energy efficiency set by 2020. The forecast for the next decade is the evolution toward smaller vehicles, environmentally friendly and easily manageable for the urban use. This future sustainable mobility pattern is planned to offset the negative effects of pollution and congestion in cities.

One of the key elements for the success of electric mobility in urban environments is the selection of those cities that can provide “a priori” better conditions for the use and implementation of electric vehicles, as well as support for the creation of favorable conditions to build and operate a network of stations for electric power supply.

The electrical producers are forcing the charging system mainly at night, in the periods with less demands of energy (valley hours). Obviously this can be a problem for the development of electric car infrastructure. Given this data, it is necessary to provide other solutions to the charge in the valley hours. In situ generation associated to parking facilities zones are postulated as a compatible solution for an overnight charging of electric vehicles.

3.4_Analysis of the Electric/Hybrid Vehicle Industry in Valladolid

Within the Smart City strategy, Valladolid City Council is boosting the growth and the future of electric vehicles in the automotive sector in their jurisdiction. So, with the cooperation of the government and the private sector, and within the framework of the European, National and Regional Strategy, they are improving the charging point infrastructure and performing priority actions to promote the electric vehicles industry with the objective of increasing the demand and exploit the economic potential of this new market.

The measures that are being implemented in Valladolid are explained below:

- Development of a network of electric charging infrastructure that support the progressive introduction of the electric vehicle, public and private.
- Adaptation of local regulations to facilitate the widespread implementation of the electric vehicle and its infrastructure.
- Adoption of positive actions to encourage the use of electric car and plug-in hybrid vehicle, in addition to the conventional model, but promoting a progressive change towards electric mobility.
- Private sector involvement in the electric vehicles introduction.
- Progressive introduction of electric vehicles in the municipal fleet, in public transport companies and the contractors of public works.
- Promotion and dissemination of electric mobility and its benefits.

3.5_PV Parking Lot Proposal

After a deep study of the Urban Mobility Plan of Valladolid and considering the increased use of electric vehicles in the city, Onyx Solar has considered that one of the most suitable photovoltaic solutions that should be proposed for Valladolid demo site is a PV Parking Lot.
This solution consists on a photovoltaic parking structure where the PV installation guarantees on-site power generation to supply the batteries of an electric car. The intervention is focused on the design of a parking module for two cars and a photovoltaic integration on the deck.

3.5.1_PV Technology Selection

The technology selected for the PV integration in the parking-lot was mono-crystalline silicon for the following reasons:

- Due to the location, orientation and planned placement, PV glass does not provide the best exposure to solar radiation (understood as such direct solar radiation in optimum angle) so it becomes critical to exploit the available area to increase installed power. Mono-crystalline silicon is, in this context, the one that provides the best results in terms of kWp/m^2 installed.
- Crystalline silicon technology allows to configure an optimal glass structural composition for the replacement of traditional finishes carport in parking (based on sandwich panel or folded metal sheet), providing an aesthetic value to the intervention and minimizing costs.

The glasses in figure 8 have been designed to cover the parking lot, optimizing the available surface due to the existing geometry of the three parking spaces.

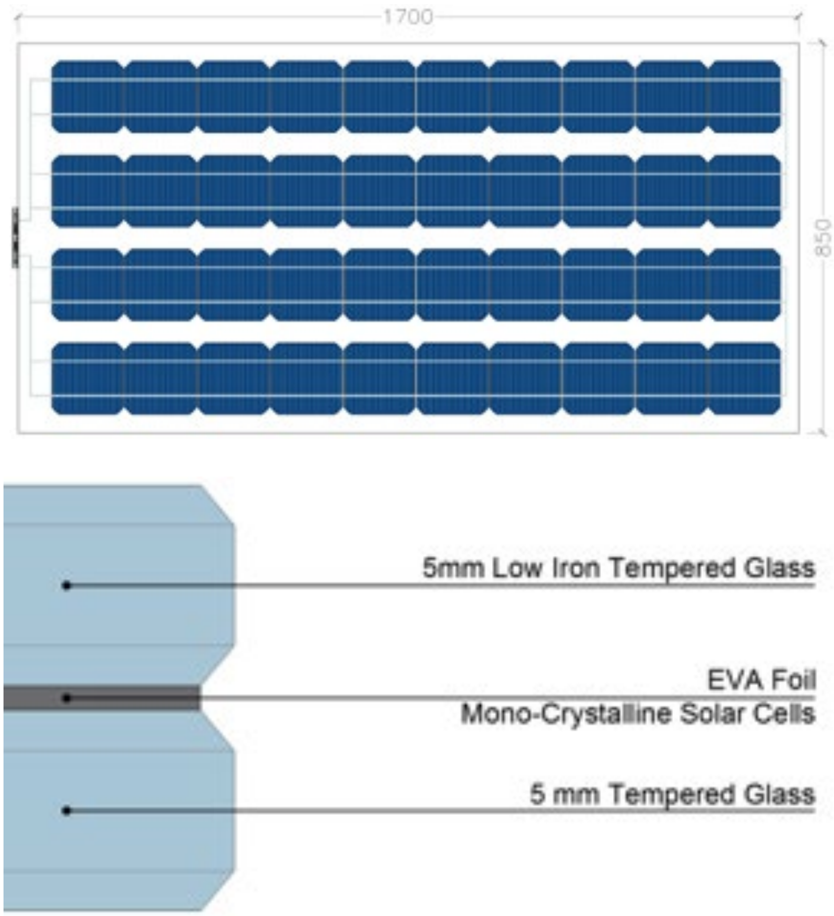


Figure 8. PV glass designed for the Parking Lot: plant and section. Source: Onyx Solar.

3.5.2_PV Structural Requirements

Different approaches can be considered to solve the structural needs for the implementation of the parking lot with a charging point for electric vehicle. In this sense the following limiting factors have been considered:

- Minimum power installation.
- Orientation of parking spaces that define the geometry of the installation.
- No volumetric invasion of the lane restrictions.

In the parking lot system proposed for Valladolid, three parking spaces will be covered achieving a final installed power of 4.17 kWp.
Different types of solutions were studied for the primary structure mainly based on two materials, metal and plywood. For both solutions, the secondary structure would be based on skylight constructive systems available on the market, allowing a watertight facing.

3.5.3_PV estimation production

The energy production estimation for the PV parking lot is shown in table 1.
The energy production of the Parking-Lot system will achieve 5582 kWh/year, based on an active integration area of 34.8 sqm with a nominal power installed of 4.17 kWp. The electric car mileage thanks to the energy generated can be estimated at 41,348 km/year.
Taking into account the accumulation system based on 4 batteries of 260 Ah 12V, it is possible to accumulate at least 7488 W (with a deep discharge of 60%), this means that we will have a current value of 32.55 Ah. If one Electric

Table 1. Energy Generated by PV Parking Lot in Valladolid. Source: Onyx Solar.
Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)
Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m^2)

Vehicle consumes 10Ah in the charging time, we can feed one Electric Vehicle each day during 3 hours.

Month	Ed	Em	Hd	Hm
January	5.90	183.00	1.72	53.32
February	9.93	278.00	2.87	80.36
March	14.94	463.00	4.33	134.23
April	17.70	531.00	5.19	155.70
May	21.45	665.00	6.40	198.40
June	24.23	727.00	7.37	221.10
July	25.32	785.00	7.75	240.25
August	22.23	689.00	6.78	210.18
September	17.20	516.00	5.18	155.40
October	11.61	360.00	3.45	106.95
November	7.17	215.00	2.12	63.60
December	5.48	170.00	1.63	50.53
Yearly average	15.26	465.17	4.57	139.17
Total for year		**5582.00**		**1670.02**

4_Conclusions

BIPV systems are energy efficiency measures that can replace conventional materials in the building envelope such us façades, skylights and produce energy from the sun and at the same time, avoiding CO_2 emissions to the atmosphere. These smart solutions can be easily implemented not only at building level, also at city level.

The PV parking lot is a perfect system to be implemented in Smart Cities as this solution allows the energy generation on-site and provide public services to inhabitants. As an example of this innovative system, a photovoltaic parking lot solution will be built in Valladolid, under the scope of the European Project R2CITIES. The parking lot will generate free energy that could be used for public lighting consumption but also, it will include a free charging point for electric cars, providing a double value to the community.

It has been proven that BIPV solutions are valuable energy efficient measures that improve the energetic behaviour of buildings in a sustainable and aesthetic way. According to this, all stakeholders involved in the construction sector such as owners, banks or municipalities should support the implementation of this type of smart solutions in buildings and Smart Cities.

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Abstract

A unique low-footprint settlement with small wooden houses in the Warsaw's centre has escaped vanishing and enters its new phase.
It has been perceived in contrasting ways – either as a living structure, a peaceful green enclave challenging the mainstream life, or as an un-modern, shameful village-like insert, occupying expensive land that would be attractive for potential prestigious investment.
The Jazdów's history dates back to the beginnings of Warsaw. Through ages, its prevailing functions related to residential, gardening and curative purposes. Today's Jazdów Settlement, situated on the former garden and hospital grounds, is a remnant of the larger estate started in 1945 when housing was scarce for those engaged in Warsaw's reconstruction. The Finnish-made prefabricated houses were part of war restitution to the Soviet Union, and brought to Poland to help emergency needs.
In 2013, the settlement avoided destruction initiated by the previous district authority (tenants pushed-out, homes demolished, eco-niche endangered). Now it has a chance for preservation and balanced development, taking a role of the socio-cultural hub, with limited residential function retained. Some houses are being adapted. Land-cultivation and eco-development impulses are expressed.
There is a chance here to build a transferable model for civic-management. The process of forming a partnership of organizations and individuals (most remaining tenants included) as well as a broader neigbourhood within the institutions in a larger area is led by such values as cooperation and openness. The research of civic-managed areas across Europe is pursued, with the involvement of sociologists, architects, landscape architects, activists.

CULTIVATING A VILLAGE IMPULSE IN THE MIDST OF WARSAW,

The Jazdów Settlement of Finnish houses

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1_Uniqueness of Jazdów Settlement

The Jazdów Settlement in Warsaw is hard to be defined in clear urbanistic categories. It's few hectares' territory is part of a long green stretch of the Vistula Escarpment (Warsaw Escarpment). The precious enclave is situated within the complex of the city's remarkable parks and may be considered as something between an urban village and an inhabited park.

From the point of view of sustainability, its wooden houses, other historic buildings and rich vegetation have formed an entity – a niche, where substantial urban interventions should be strictly limited.
On the other hand, as being part of the central district of today's Warsaw and very close to the Parliament, government buildings and embassies, it has been bearing the risk of becoming an attractive plot for investment of modernistic or stereotypically prestigious character.
Those who would like this area to be developed in a more intensive way, have often used arguments against its village-like features, describing the Finnish houses settlement as being shameful and un-modern while occupying expensive land owned by the municipality. Clear ownership rights, like in a case of Jazdów, are quite rare in Warsaw where much of property, nationalized after the World War II, tends to be claimed back by previous owners or speculators.

On the other hand, those who would like to protect the Jazdów's nature and rare wooden buildings, describe its values as "priceless", non-material. Many even propose that the existing landscape should be saved "just as it is" – at least without major changes in its structure and specific atmosphere.

1.1_The place's history, character, atmosphere

The character of the Jazdów Settlement's unique landscape has been shaped by the morphology of the Vistula Escarpment, the land-cultivation and curative impulses. The identity of Jazdów has always been bound with the core of the history of Warsaw as well as the history of Poland.

Through ages, the identity of the larger area called Upper Jazdów (or Ujazdów) was shaped by residences, parks and gardens situated along the Royal Route on the escarpment.

Jazdów dates back to the times of the Dukes of Mazovia's presence (12^{th}-15^{th} Centuries), their castle situated on the cliff, securing a strategic river-crossing nearby to the east.

Bona Sforza, the queen of Poland (in the years 1518-1557) had her manor in Jazdów, with an Italian garden. She is famous for introducing a number of vegetable species that are still basic atributes of Polish kitchen. In the 18^{th} Century, Jazdów became part of one of the largest urban east-west axial layouts of Warsaw (Stanislas Axis), with sophisticated geometrical compositions, parks and gardens.

On the today's site of the Jazdów Settlement, there existed a village (relocated to the main line of the Stanislas Axis around 1780). The road leading to the village was called Village Street (Wiejska), owing its name to fields and gardens located between Jazdów and Warsaw developing to the north. To this day, the Polish Parliament has the address Wiejska 4/6/8. The historical name of another street bordering the area was "Healthy Street" (strangely enough, this name has been "relocated" and is used today for one of the new streets in the outskirts of the city).

From 1794, army barracks and hospital brick buildings were developing in the area. In the end of the 19^{th} Century the romantic Ujazdowski Park was laid out on the site of the former military drill square between the main avenue (part of the Royal Route and Calvary Road - Aleje Ujazdowskie) and the hospital grounds.

The dominant hospital function remained here till 1944, in its last years serving the war victims. Some of the hospital buildings are still on their positions (three of them standing among the Finnish houses; one of them still used as day-care department of the Nowowiejski mental hospital). In the history of the area's military and curative usage, local gardens served self-sufficiency, but during the war and until 1951 they were partly used as a provisional burial ground.

From the summer 1945, first inhabitants were moving to Finnish houses assembled fast in free spaces of the former hospital site. The tenants were mostly engineers and architects employed in Warsaw's reconstruction. Their provisional houses were supposed to last here for 5 years.

History has come full circle – new houses and their green surroundings related again to the primary character of the habitat, and especially to the historic village, with its gardens and orchards.

The new settlement, being a council estate, was planned as temporary, but much of it has survived to this day. What is remarkable is that the single-family humble houses from the war period, having the size of huts (about 50-60m^2 existence-minimum area each) served tenant families well enough to spend most of their lives here. Compared to all other council flats in Warsaw, they were so different; not easy to maintain but very much appreciated by their inhabitants and often arising jealousy among those who looked at them as an example of luxurious country-living in a specific community in the most attractive city district.
The houses were ready-made, but many of them have undergone transformations. Some were extended according to specific family needs. Some of them present modest "spontaneous variations".

Today, the atmosphere of the Jazdów Settlement may in places remind allotment-gardens developing in an organic way or a piece of a garden-city, or a village with a Scandinavian touch.
The visible features of this green enclave may be associated with *generated structures* of which Christopher Alexander writes in the context of *living processes*. "ALL the well-ordered complex systems we know in the world, all those anyway that we view as highly successful, are GENERATED structures, not fabricated structures".
The houses themselves were, literary speaking, "fabricated structures" in respect to their primary design, but after decades and some transformations, they play a subtle role in a generated landscape, where nature has got a dominant role. The houses' special feature is that they could have been called "sustainable", if this term were used in the time of their construction. This is for many reasons, not only because organic materials were used, but also for their modesty and flexibility to adjust to needs of their users. To continue the Alexander's language, the Jazdów Settlement, as a whole, would most probably arise "more from the process than from an imagined design".
There was never any carefully detailed lay-out plan elaborated for the Settlement. Everything was happenning fast after the war had ended, and many solutions were provisional then. The habitation was formed by some houses situated in a line but mostly in clusters (small-scale neighbourhoods) placed amongst trees of various species. Modest hedges, low fences and more organised paths came later, when the inhabitants felt it necessary to achieve some privacy for the family and protection from intruders. They also wanted to care for their gardens much better than the municipal services could.
One can feel all grades of spaces here – from public to private. Morphological similarities can be found between the Jazdów Settlement and habitats of a similar history, for instance in Silesia or in another district of Warsaw (Jelonki), where the Finnish houses were also built. Comparison can also be made of the atmosphere of Jazdów to the Finnish examples – like Puu Käpylä, the first larger area of wooden prefabricated houses (1926), based on the garden-city models. The other Finnish reference are the same types of prefabricated houses as in Jazdów that are still in a good condition in some locations in Finland. Nevertheless, none of the comparable examples are in the central part of the city like it is the case here.

Figures 1,2. The landscape characters of Puu Käpylä in Helsinki and Jazdów Settlement in Warsaw.

1.2_Contemporary planning and ideas versus the identity of the Jazdów Settlement

When Poland was recovering from many years of annexation and from 20th Century wars, this part of Warsaw was to play its role in the renewal efforts. Two years before the time Poland gained its independence in 1918, there was a concept drawn for the general plan of Warsaw, in which a large complex of major Polish state administration buildings was proposed on the Warsaw Escarpment in the area of Jazdów. The competition for the Ministry of Foreign Affairs headquarters followed (1926). The entries presented gravely visions of the space where the Jazdów Settlement exists today, exchanging the hospital buildings by a monumental ministerial edifice.

The competition results were met with strong and conscious criticism in professional circles, as showing the proposed solutions as inadequate for the area. Anyway, the Parliament complex, developing just next door, seemed to be a kind of neighbourhood good enough to give way to situate similar functions here. This has not happened on such a large scale. Although there have been a few major urban ideas or interventions (including the decisions now and then to remove the Finnish houses), a "real" urban plan for the area that is now the Jazdów Settlement has never been elaborated.

The French and German embassies (1967-71; 2005-2007) were supposed to be the first to start the development of more buildings of this rank on the successively "cleaned" site of the Settlement. To build the embassies, tens of houses were removed.

The years 1971-74 marked a major change on the map of Warsaw, as the motorway crossing the escarpment and cutting through Jazdów was built, dividing the area and causing removal of another number of Finnish houses. In connection to this, in 1972 the "final" decision was taken (but not realized) to remove all of the houses till 1974.

From the beginning of the Polish transformation in 1989, the area started to draw attention again – as a valuable potential ground for investment. As the Settlement was never meant to be permanent, in the administration's thinking it was treated only as a building plot.

With the end of the communist era, there came the time for independent architectural and planning practice. Andrzej Kiciński – architect and urban planner, proposed – as a part of the study for the local plan – the formation of the National Park of Art and Culture in the area of Jazdów, as an expression of the idea of the "Agora of Polish Democracy". The concept was to preserve some of the characteristic features of the area (small scale, new buildings scattered among greenery). Any residential function was excluded in the concept and the Finnish houses were meant to be removed. The interesting feature was the continuity of the Warsaw Escarpment, to be achieved also by covering the motorway (or rather by putting it into a tunnel).
A similar idea was used in the 2009 competition for the Polish History Museum situated (or "hung") over the motorway, on the edge of the Jazdów Settlement, influencing its life crucially, mostly ignoring it or just liquidating.
What is especially interesting is the fact that in the winning Polish History Museum's project, the protection of all the Finnish houses was envisaged, although their function was not a topic then.

In the meantime, in spite of permanent lack of any transparent concept, nor any formal plan for the area, the district authorities decided to "empty" the Finnish Houses and take all of them down. The efforts of removing the tenants started to be more intense. In 2012 four houses were taken away from their sites for a start. What is interesting, they were later found in pieces in another part of Poland – advertised for sale.

Figures 3,4. The material substance of the Finnish Houses has a chance to be reused or recycled.

The plan to build the museum was cancelled in 2014, even before the Study for the general plan of Warsaw had been adjusted in order for its planning permission. The time of this cancellation (or rather of changing the location for this museum) was announced, coincided with the workshops organised within the framework of public consultations on the future of Jazdów.
The recommendations of the consultations were promising both for the development of citizen-democracy in Poland and the future of the Settlement playing an important socio-cultural role in Warsaw.

In 2015, the newly elected district authorities decided, that no more Finnish houses would be demolished, no more tenants removed and that there would be a possibility to enliven empty houses with various activities. First agreements with non-governmental organisations having socio-cultural and

ecological profiles, were signed for the period of one year (the time contested by new tenants as too short).
The history has anyway made a new turn. Even if temporarily, the settlement may play a positive, creative role for Warsaw's development.
In spite of the new decision, promising a new perspective, no clear future for Jazdów, from the point of view of planning, has been inscribed. Nothing is stabilized from the formal longer-term point of view. Aside of actual policies of the district authority, there is an undercurrent of contradictory opinions among urban planners and architects concerning the Settlement's future. The non-governmental organisations are often felt as associated with city-activists who often protect vulnerable areas from over-investment.
The local plan has been in its design phase for years now. Its latest concept has been very simplistic, technocratic, taking neither the genius loci, nor any wider civic-society's needs into consideration. It just followed the general Study, in which Jazdów's destiny is administrative functions, eventually joined by services. On the other hand, a common practice has been that lack of a plan is also a kind of a plan.

In order to be able to get a realistic input into the local spatial development plan, the architectural and urban design competition has been prepared but not launched. Maybe luckily – as there is a question if the competition would solve the problems which are rather being successfully dealt with on the grass-root level and according to the public consultations' results. There is an idea for the bottom-up plan to be prepared.

1.3_The potential gathered in Jazdów over last years

As the year 2012 marked a real threat to the Settlement endangered with demolishing, it caused reaction. While the process of displacement of tenants was pursued and houses started to be taken down, the efforts for the preservation of the Settlement started. An important role was played by the Finnish ambassador, who even called upon sentimental bondage with his father supposedly working in the factory in which the houses were primarily constructed.
The working group was co-organised and hosted by the embassy and the Jazdów's tenants association, to discuss the future of the Settlement, or at least just save a few houses, where cultural activities would take place.

Wider interest arised in 2013, while Jazdów was part of the Night of the Museums, with many houses and gardens open for activities as exhibitions, talks, meetings, concerts. The openness and inventiveness were still widened when the Open Jazdów (Otwarty Jazdów) initiative was organized, with many of the houses and gardens coming back to life for a few months of summer. During the following season, the Social Dialogue Square was created in the centre to host music shows, film screenings, etc. Garage sales were organized. An apiary was situated around one of the houses and the Queen Bona's gardens were in a way re-started. Some houses and their gardens started to partially re-used. That year was marked by much pressure from the side of organizations and enthusiasts but there was little activity on the municipality's side.

The neighbours from the Centre of Contemporary Art - Zamek Ujazdowski joined in to fill the surrounding open spaces with more public life, by organizing the Green Jazdów summer initiative, during which there were also an exhibition and public meetings organized concerning the future of the Jazdów Settlement.

Social processes once triggered, are encroaching larger and larger areas in and around the Jazdów Settlement. There has been a large potential gathered of activities like workshops, study visits, architecture education activities for children and youth (like the planning workshops of the Children's University on the future of Jazdów). Five diploma works were made on the re-usage of Finnish houses by students of the situated nearby Interior Design Department of the Academy of Fine Arts. There were landscape architecture workshops of the Warsaw University of Life Sciences. The Faculty of Architecture of the Warsaw Technical University students had their surveying practices and workshops. The results of Polish – Finnish interdisciplinary design workshops on the themes connected with the visions of the future for Jazdów were shown during the exhibition "Warsaw under Construction". These are just some initiatives, but there have been many more – adding to the potential gathered for civic-management and bottom-up planning.

Figures 5,6. The multilateral communities – the Polish-Finnish working group in 2013 gathered to protect the Jazdów Settlement; the 2015 development of city-gardening (photo: Motyka i Słońce).

The local community, as well as broader, diverse groups have consolidated and a large number of sympathisers are gathered around many initiatives. The integration was getting strong in reaction to threat, what is often the case, but the public consultations (co-organized by the Centre of Social Dialogue of the City of Warsaw and led by an interdisciplinary team of MIASTODWA) have played an important role to bring in and connect many groups of interest and work with positive motivations.

The public interest and debate has influenced at least the moods on the side of the official administration body (ZGN; Real-Estate Management Administration) and better relationship with the district authorities developed. The change of approach and increased visibility, meant more tolerance and the change of policy.

Cultural and socially-oriented activities are being more and more imprinted in the physical space.

The *generated structure*, as described by Christopher Alexander, is continuing to develop as a process, without planning "from above".
Although during last few years not much has changed in Jazdów in respect of its basic structure, there are many examples of spontaneously planned and realised interventions. Some houses got new users, their surroundings got new community gardens, some garden spaces that were "semi-privatized" are becoming still more open. The central meeting space (the Square of Social Dialogue) was enriched with its simple wooden furniture (financed by the municipality as the Local Initiative; the hand-working by volunteers).
One of the abandoned houses has been renovated and adapted for the new function of the "Rotary" House of Culture (open for short term socio-cultural activities organised in turns by various entities).
There are also other projects realized here, but until there is a more clear urban development plan, it is not possible for the new tenants (non-government organisations) to invest much in the renovations.

2_The performance of Jazdów Settlement in the year 2016

The Jazdów Settlement's hundreds of everyday users can be recognized as groups having differentiated interests and rhythms of activity (residential, educational and socio-cultural, curative, gardening, recreational, administrative).
Presently there are 27 Finnish wooden houses, 7 of them still inhabited by the tenant population of about 20 persons. Inhabitants of the council flats (Finnish houses) are more or less integrated into the local community as a whole.
By the entrance to the Settlement, close to the French and German embassies, there is the primary school (for about 400 pupils). Among the houses there are three 19th Century brick buildings (remnants of the military hospital). Two of them house the kindergarten (around 100 children) and the Day-care Department of the Nowowiejski Mental Hospital (around 30-60 patients). The third brick structure has been allegedly perpetually leased - from 1990s, when many "strange deals" were made between public authorities and private investors. It has been empty for some years and it is difficult to find any facts on its status.
There has never been any solid survey done, nor any research on the technical performance of the Settlement. Basic city services are in place, with the exception for heating and hot water for the Finnish houses and the mental hospital. Individual energy solutions for them have been one of characteristic village features of the Settlement, although one can also say it has been a policy of the administration, as the houses were meant to be demolished and the hospital sold on free market. These were left to be solved by inventive users, usually adopting traditional wood or even coal burning stoves and electric devices. Some houses have been additionally insulated, although a larger number of them are just left as they used to be from the time they were erected – with a thin layer of fibreboards in the walls.
The present purpose of efforts to overcome the Jazdów Settlement's crisis of becoming dysfunctional, is to fill all the existing structures and gardens with activities and not to lose the all-time inhabitants.

2.1_Striving for sustainability versus temporary status

The brick buildings in the Jazdów Settlement's area are listed. It does not mean they are under a real protection, being maintained in a proper way, but at least they cannot be demolished in the face of law.

The Finnish houses are devoid of any conservator's protection. Some of them have been cared for by their tenants, some neglected (any investment in uncertain accommodation was understandably doubtful).

Solid public buildings of the Jazdów area can be associated with stability and permanence. The case of wooden houses is different. They need extra protection as they are fragile, defenceless, "poor by their nature" and it has always been like this with wooden structures in the Polish history. There is scarcity of timber structures, especially in Warsaw.

On the other hand, the Finnish houses have their own extraordinary chance as they can be understood more as belonging to the organic and non-urban world and thus being a rarity in the middle of Warsaw.

The other advantage is that they are characterized by natural dynamism of changes, mobility, diversity – the features looked for, when sustainability is striven for. The defenceless houses call for their their protectors. They can be repaired faster and cheaper than heavier structures. The dedicated individuals among their small population are helped by many "from outside" in these efforts.

The adaptations of neglected wooden structures prove to be an uneasy and risky venture from the financial point of view, especially as the agreements for their usage are very short term (one year) and their status has to be formally changed from residential into public-use. In winter, only two houses being in the best technical condition are used as minimum-spaces for everyday use and community meetings.

2.2_The hub for socio-cultural and eco-development activities

The danger of neglect and destruction on one hand and the grass-root efforts to protect the Jazdów Settlement on the other, brought many like-minded individuals and organizations together. The crucial step for the tenants on a very local level was to form the Association of Inhabitants of the Finnish Houses in Jazdów. Its activists had been taking all kinds of initiatives to arise more interest and, first of all, to reverse the former district authority's decision on demolishing the Settlement. The controversial decision was cancelled but because of uncertainty, there are less and less tenants left in the Finnish houses. Most of them feel connected with new initiatives of opening the settlement for socio-cultural and more public life, although there are also some that protect their privacy still more. Both strategies are set for survival, but one can admit that those who are open are the avant-garde of the protective as well as development efforts.

Now, there are tens of organizations either using the houses and gardens or preparing to use them for their statutory aims. The topics tackled are such as: sustainability and ecological lifestyle (low footprint; assessment methods and optimization in planning), heritage protection, city-activism, continuation and development of therapeutic character and functions of the area (development of city gardens), cultural and educational initiatives (with a possibility to cooperate with local schools and kindergartens, with the hospital, neighbouring embassies and public institutions), sports, scouting, cooking with refugees or folk music.

There are possible exchanges and coalitions with similar territories (areas or enclaves protected and developed by local communities). There is also a collaboration developing among the institutions within the city district of Ujazdów, in which the Open Jazdów (Otwarty Jazdów) as the Partnership for the Jazdów Settlement is an active member.

3_The Partnership for the Jazdów Settlement

In the last years, the activities of the community that gathered in and around Jazdów had a character of a coalition. In 2015, the Partnership for the Jazdów Settlement was formed as an informal group of interest, gathering the interested individuals, institutions and organizations, with the hope to work with many issues concerning the everyday management in a grass-root way and hopefully in cooperation with the municipality. There are a few working groups: Environment and Building, Social Economy, Civic-management, Culture and Education. The Partnership has a chance to work out a model of such management and advocacy for the Settlement that would fit most its character and enhance the community spirit.

The coordination has been teamwork, although there is one person holding most of the links – a kind of a village chief – a person living on the spot (Andrzej Górz). Working in the partnership is a chance for a growing number of people (both the tenants and those "from outside") to participate, as well as for networking – to build a natural (and so sustainable) self-governing structure.

3.1_Research into urban autonomies, directed to work out the governance model

The Jazdów Settlement has a chance for some experiment in autonomy, not having to depend on questions of land ownership. Uncertainty of the users concerning the future plans of the land-owner ("the city") is an understandable problem though. The fact that the land belongs to the municipality (meaning everybody) may be treated as disadvantage on one hand, but an advantage on the other (as far as there is dialogue, understanding and will to work out a common set of values).

For the city administration and services, such a kind of settlement has always been an uneasy case to deal with. The routines are often not in tune with the area's specific character and this is not only the problem of Jazdów. In the comparable estates in Helsinki for example, the way the authorities imagine "spatial order" may also be not in tune with the philosophy or style of life of local inhabitants.

It has been suggested by the Partnership for the Jazdów Settlement that all projects concerning public space improvements or just changes within the public spaces in this area were postponed until a general concept or the awaited local plan are worked out.

To find the best civic-management model, the study supported by the European Culture Foundation has been launched. Its goal is to research the similar cases in Europe in order to develop a practical formula for cooperative, cross-sectoral, community-based management for the Jazdów Settlement.
The research phase is to choose and analyse the best practices of creating and functioning of community managed entities (the best if having a special legal status compared with such as those of cooperative housing, trade co-operatives, allotments, etc.). The development phase is to bring together partners from the municipality of Warsaw and other foreign as well as Polish partners, to tailor two solutions: the model of management for the Jazdów Settlement and the regulations for the City of Warsaw that would allow for collaboration between the municipality and the Jazdów Settlement, to sustain Jazdów in the long term.
The study is to find out what experiences are possible to share between similar places-initiatives (specially of a certain level of an urban autonomy). The criteria were set to compare the Jazdów Settlement with other places of similar character:

- inhabited (a least to some extent);
- physical space larger than one building;
- characterized by diversity and accessibility;
- growing out of civil society initiatives;
- the property and usage status formally regulated;
- the managing organization diversified, multi-sectoral;
- the activity agenda open to all users, with a character of public mission;
- inclusive;
- transparent (everybody may participate or follow the processes);
- sharing-economy elements included;
- an ecological agenda (self-sustenance, renewable energy, ecological education).

3.2_Jazdów as a possible expression of citizen democracy

A few inhabitants of the Jazdów Settlement were not representative enough to be recognized as a citizen group to have a strong, valid voice. They seemed easy to be dealt with, when the “clean-up” policy was implemented - to remove tenants and houses from the area. Scared and unable to react, while the steps of the municipal authorities were offensive and consequent. There were losses as some houses were taken down and a number of inhabitants have left the place.
Fortunately, some of them proved to be able to stay. It seemed natural that a larger community would soon gather around those endangered as the place itself having this particular character proved to be needed by a larger population. In result a shared feeling of ownership, as well as strength of togetherness have developed. Once defended, the community started to organize, both from the inside and outside, what meant many forms of cooperation between the inhabitants and a larger community, including local council members and municipality workers. The negative situation may be shifted into positive.

3.3_Conclusion. Would the model of Jazdów be transferrable?

The partnership model worked out, to practice a certain level of urban autonomy, especially for a unique *generative structure* like the Jazdów Settlement is aimed at sustainability in everyday practice.

Active communities characterized by openness and diversity have a chance to perform as hubs of urban knowledge and experience. If only they are allowed to survive and – still more – supported to develop, their feedback, or rather their mission, may be to influence the basic city policies and help with their implementation, as well as transfer the achieved results further on.

Multilevel urban governance, and especially the community governance methods may be enhanced if civic-managed areas are allowed to flourish. The research in civic-management and experiences of the Jazdów Settlement's last few years may prove that citizen empowerment may still become stronger through the art of working together in a challenging situation of a village-like settlement in the middle of the city.

It is possible that small communities (autonomous to a certain extent) and municipalities may come to agreements in order not to govern in a schematic way but to cooperate, allow for a free flow of exchanging ideas, knowledge, experiences.

Citizen involvement put in practice may go parallel with conscious policies of public administration, thus marking substantial progress in development of everyday democracy and fulfilling global goals of sustainability in its holistic meaning.

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Abstract

The theme is dedicated to the problem of urban heritage preservation in the era of globalization with the rapid growth of large cities and megalopolises. The object of research is the Old Town designed in the period of urban and politics reforms of Russian Imperial age. Only in the last 100 years, the territory of modern Russia has undergone numerous reforms and political turmoil. During the research there were studied Moscow as the capital of Russia and some other Russian cities with their historic urban landscapes integrated with contemporary architecture, and also the problems of transport situation of these cities were analyzed. In the last decades the low-rise residential quarters with historical favorable ambience are demolishing; on their places skyscrapers have been building, constant migration from residential areas to the centers and the growing number of vehicles, parking lots are not sufficient.

The aim of this paper is to show the opportunity for preservation of the architectural and landscape heritage in the historic city centers of Russia with a glance of contemporary social requests. Based on the study of information and on the documents of conservation of historic city centers, the opportunity to preserve the urban and architectural heritage is offered with new regulatory standards of urban development and of the use of land in the most valuable historical urban areas. The solution was found in the creation of pedestrian areas in the major public city centers.

INTERCONNECTION OF OPEN AND CLOSED PUBLIC SPACES IN HISTORIC CITY CENTERS IN RUSSIA

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1_Urban heritage of the Russian Imperial age

Catherine the Great on the 25 July 1763 issued a decree for the creation of specific plans for all cities and for each province separately. According to the decree, the Commission should supervise the preparation of plans and the construction of cities of the Russian Empire. From that moment, the highest approved general plan became a fundamental planning document having legal status. The new planning of the streets, alleys and squares were performed with allowance for the existing of old buildings, but with mandatory rectification of streets, enlargement of wards and giving the regular shape of the squares. Districts around Central Square and the surrounding streets were signed under the stone buildings. A residential homestead with a complex of household buildings on the mansion (stable, coach-house, woodshed, and hayloft) became the main type of urban development of the period from 1780s. Alexander I, Emperor of Russia, during whose reign the victorious conclusion of the Patriotic War of the year 1812 and the burning of the majority of houses

Figure 1. Pyatnitskaya Streeet, the end of XIX century and the middle of XX century. Painting is made by Shalaev A. in 2008.

in Moscow brought a new unusual strong growth of building construction. 5 May 1813 the Emperor kept a decree on the establishment of the Commission for the construction of Moscow's state with a large amount of manpower and three brick factories. The commission was composed of two parts: surveyors and architects. It was the surveyor's job to make measurement of all parts of the city, streets, squares, streets and neighbourhoods. Based on the data obtained it was necessary to compose the new geometric plans. From architects it was required to create the plants and facades, monitor the construction process and the quality of the materials produced in brick factories. The government of Alexander I attributed great importance to the construction of Russian cities, especially of their centers. It was entrusted to the capital architects to design the facades of residential buildings of various sizes and number of planes and sending them to the provinces. Every December the governors were must report to the Ministry of Interior statement (on a special form) about the quantity of houses built in the city on these facades with the registration number of the facade, taken from the album. The architecture of this period is characterized by the Russian classicism with geometrically regular plans, consistency and firmness of symmetrical compositions, rigorous harmony of proportions and the widespread using of an order tectonic system on the facades. In 1839 plans were announced for 416 cities in the Complete Collection of Laws of the Russian Empire. The Commission completed its work in 1843.

The functionality of the grid of streets-corridors has been already exhausted at the beginning of the XX century, but this technique for a long time still remained in the arsenal of urban planning. Development of electrification, gasification, automation and technological advances has led to the fact that the existing architectural and planning system could not perform new functions. Cars, buses and trams replaced horses and carriages; machines and mechanisms replaced manual labor; villages, towns and small cities gradually began to decline, and medium and large cities began to grow noticeably. The functional relationships and processes got more complex and it became increasingly difficult to organize them in confined spaces and volumes, subordinating them to compositional techniques inherited from classicism, based on symmetry and static equilibrium of the masses. The process of the evolution of urban planning became a natural consequence of industrialization.

Since 1918 noble residential quarters in the historic city centers ceased to be privately owned, and became the property of the state. Practically there are no buildings of the Russian Empire in the historic city centers, preserving the original function of housing and the internal organization of space. From the 1990-s with the change of property laws and with the beginning of privatization of state property, these buildings became ownerless again. In the 21th century the problem of urban heritage preservation in the age of globalization with the growth of population, the increasing number of vehicles, the felling of green areas and the construction of skyscrapers, often falls outside the scope of interest of contemporary architects-practitioners, which project buildings with the maximum number of usable area on small expensive areas of land in the historic city centers.

2_City center's importance in the system of public spaces

In the examples that could show the difficulties of modern urban development, there are no deficiencies. Most modern residential neighborhoods represent sleeping satellite towns: the people did not choose these cities; they are created with the sole purpose – to sell more apartments in residential complexes built on the land with the minimum allowable building area. These buildings provide nearby enterprises with a labor force and trade mega-markets with buyers. Critics have repeatedly noted the poverty of the architectural appearance of such complexes, streets and courtyards, dreary monotony of the facades of houses and public buildings, serious miscalculations in the massive proportions of volumes and spaces, gigantic forms that interferes with their visual communication with a person and doesn't conducive to creating a comfortable and living environment. This is a consequence of serious blunders in dealing with architectural and creative tasks, and often of neglect the objective direct composite laws. Proximity to the workplace is a small advantage, since most jobs are still in the center of the main city, on which depends the satellite town. The buildings of factories and plants, founded on the outskirts of Moscow a couple of centuries ago, now occupy central urban areas. The digital age has replaced the era of scientific and technological progress, which in turn was succeeded by the age of industrialization. Transport and environmental problems have led to the reconstruction of the large city centers, to reconstruction of the production and industrial enterprises and their adaptation to the public multi-functional complexes and business centers. Considering the existence of complex forms of urban space, the question arises, how they relate and what effect they have on the formation of the differences in the various spheres of social life. The main social center of the modern city is not only the main architectural ensemble and vanguard in a system of social and cultural services. It is a comprehensive functional area in which social and political work and management, culture and recreation, transport functions (center – a major transport nodal point) are implemented. The uniqueness of the center, its exclusiveness in relation to all other elements of the city are determined not only by the fact that it collects a higher pattern of activity in different areas, but also the choice of behaviors, activities, forms of communication. It always has been, and so it is natural that the town center was filled with the most valuable architectural buildings, works of landscape art, sculpture, fountains – all that not only improves the comfort of home, but also creates a valuable independent spectacle. Numerous studies confirm that a very large proportion of the visitors center called the goal of his movement to the desire "to stay in the center," to feel its atmosphere. The city center always represents the greatest interest for residents and tourists, and investors, government and public organizations.

Urban architectural and planning structure can be seen as an art of spatial organization of work, life and recreation. However, in the digital age the concept of architectural space should take into account additional components – time and speed: the perception of space the city streets and squares is different from the perspective of a pedestrian walking and from the viewpoint of a racing car driver. The problem of public space is a complex set of psycho-physiological, social, aesthetic, and other factors. The space in the architectural composition is understood as limited, partially restricted or not material restricted part of the real space. In constructing the system of open public spaces in the city, it is important, first of all, to build a backbone frame – a complete network, including public buildings and structures in the system that will add integrity to it.

One example of where the integrity of the network backbone was broken it is the reform of the State Library named after Vladimir Lenin in Moscow. A significant portion of its assets in 1970 was taken outside the city, in the town of Khimki. This not only increased the cost of extremely unproductive time readers to move, but in many ways to disrupt the work of the library as a scientific institution. The reform was carried out without attention to the adjacent Old Town quarter, which at a reasonable reconstruction of the library could double its space without breaking the concentration of its activities in a habitual place for people. Moreover, the concrete analysis of the situation reveals that library developing in its old place has the ability to substantially link up with the expanding Museum of Fine Arts and Museum of Architecture, which would give an opportunity to organize the Museum and Library Quarter in the historic area. In city center, depending on its size and planning organization should formulate a system of interconnected public open spaces (the main streets, squares, pedestrian areas) and closed spaces (areas in buildings and structures). These spaces must be logically linked, available to people for the normal functioning of the whole city.

The reconstruction of ensembles areas and systems of landscaping is also important. Do not forget that the composition of public open space arrangement is directly dependent on pedestrian accessibility – the value of the urban zone influence of the object is determined by the maximum possible area pedestrian accessibility. It is extremely important to carry out these measures in a complex. Such an approach to solving the problems of open public spaces will allow to reconstruct any city and to improve its architectural appearance.

3_Old Street as a new element of urban development

I previously had a very strange idea: I think it's quite not hurt to have in the city of one such street that accommodates itself to the architectural chronicle... This street would have done then, in some respects, the history of development of taste, and who is lazy turn over thick volumes that would have had only to pass through it to see everything. (Gogol, 1835)

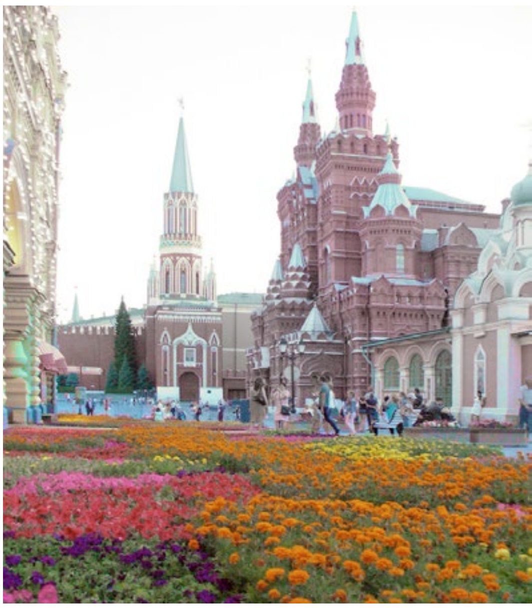
The appearance of horse tramways, tram, and then the car breaks the fragile harmony of streets and roads. Containing thousand vehicles, the road cut into the body of the city, breaking the safety of its traditional boundaries. At the beginning of the XXI century the city road pushed pedestrians into narrow pavement. Attempts to protect the sidewalk from the proximity of cars and exhaust gas led to the practice of urban planning in the sustained expansion of "street" and thus – to its disappearance. Often the opposite pavements have to link the underground passages because of the organization of parking next to the building where once was pedestrian traffic. Car parked badly, it can create difficulties in the movement not only of other cars, but also for pedestrians.

Moscow architects and urban planners found a way out of the situation in the city center, turning the old streets and alleys in the pedestrian. This idea came from a situation where from point A to point B has become easier and faster to walk than to drive between them. The plan is now implemented quite deliberately, to unload the center of the vehicle, and for an easier interconnection of public open and closed spaces.

Reconstruction of Pyatnitskaya Street is an example of an integrated approach to organization of quality pedestrian space in the city center. It is one of the oldest streets, until June 2014 it was an important traffic artery of historical conservation part of Moscow. The movement of vehicles on it was one-sided into the city center; it had four lanes with a total width of 14.6 meters of the carriage-way without cycling infrastructure. After reconstruction Pyatnitskaya Street became a comfortable space for pedestrians and cyclists. The roadway was narrowed to two lanes and pavements were widened to six meters and paved with granite. Within the bounds of the project also pockets of parking, public transport and lighting were equipped; benches, bicycle parking, and boxes have been installed. Work on a further improvement of 54 yards, adjacent to the Pyatnitskaya Street, was conducted. Almost all the 66 objects of cultural heritage located here have been renovated, and reconstruction of 10 monuments of architecture has also been completed. St. Clement's Church, Church of St. John the Baptist by Bohr and the house built in the late XVIII – early XIX centuries were restored at the expense of the city budget. As a result of the project, in the historic center of Moscow, another one comfortable public space appeared for everyday life and leisure Muscovites and visitors. Citywide fairs, festivals and celebrations are held on the pedestrian street.

There have also been reconstructed Nikolskaya Street leading from Red Square to the metro station Lubyanka and Klementovsky Lane leads from Pyatnitskaya Street to Tretyakovskaya metro station. These streets today are exclusively pedestrian areas connecting large open spaces with objects of public transport and create a favorable environment for visiting closed public spaces – the central department store (GUM), cafes and restaurants,

Figure 2. Close public spaces of the building of GUM and open public spaces of Nikolskaya Street after its reconstruction, summer 2014. The festival of flowers.



trade and service facilities, theaters and museums. In Moscow's historic center in the period from 2010 to 2016 during the improvement work there were organized pedestrian streets and zones with a total length of about 100 km. This fact only proves that the pedestrian streets and areas in the historic centers of Russian cities are an essential element in the present stage of urban development.

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Abstract

The EU imported 54% of its energy sources in 2006 and was projected to increase even further by 2030. Reducing its import dependency is one of the main goals of the 20-20 by 2020 target – this legislative package is believed to reduce the expected imports of energy by 26% compared to the development before the 20-20 initiative. On 24th October 2014 the European Council approved the 2030 Framework for Climate and Energy, proposed by the European Commission with objectives to be met by 2030:

- *at least 40% reduction of greenhouse gas emissions by 2030, compared to 1990;*
- *at least 27% of renewable energy used at EU level;*
- *an energy efficiency increase of at least 27%;*

One of the most important environmental problems is the energy consumption of the buildings.

Present paper focuses on the residential buildings built with industrialized technology, and their potential in nearly zero-energy buildings sector. Up till now the Central European support schemes concentrated most financial resources on buildings built with prefabricated technology. Present paper explains the past and present of the "panel" problem in Hungary with a short outlook to some other countries in the framework of nearly zero-energy building standards.

BUILDINGS BUILT WITH INDUSTRIALIZED TECHNOLOGY

Towards Nearly Zero-Energy Buildings in Central Europe

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1_Prefabricated building stock

1.1_"Panels" as dwelling units in Hungary

The name "panel" is a term used in Hungary referring to the prefabricated (mainly residential) block of buildings built between 1950-1990. Since this was the main urban housing type of the Socialist era, it is a common sight in the former "Eastern block" countries, often dominating the townscapes.

The panel technology widely used in the former Soviet Union was actually invented at first in Western Europe. It was applied in Denmark, England, France and other countries. The Soviet Union bought the technology and developed its own system. In Hungary Soviet and partly Danish systems were used more or less modified by Hungarian engineers (Preisich 1998).

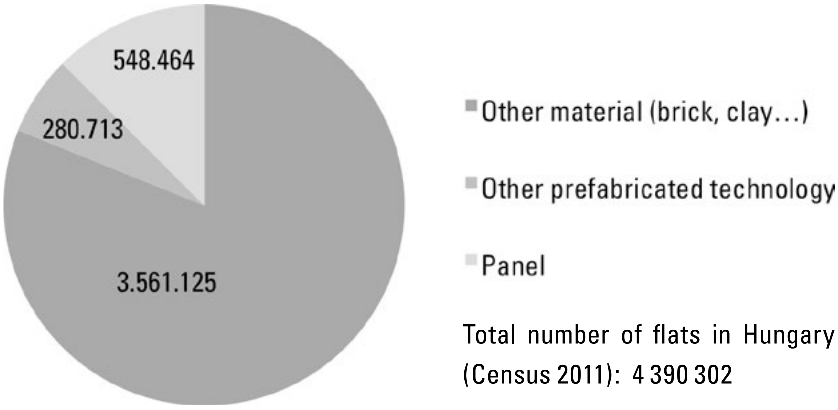
After the II. Word War fast population growth and urbanisation occurred which resulted a housing crisis. Budapest and other bigger towns became overcrowded. The town and city cores this time consisted mainly single or few-storey dwelling units or worker houses. To answer the problems the government bought the "large panel" technology to be able to rapidly construct standardized dwelling units often by demolishing the existing fabric or creating entirely new neighbourhoods on former farmlands (Perényi 1967). These buildings often provided improved living conditions for the inhabitants with piped hot water, flush toilets and district heating.

The ratio of condominiums built by panel and other industrialized technologies slightly exceeds the ¼ of the number of the total condominiums in the country. Prefabricated and panel buildings still dominate the Hungarian cityscape. The share of panel dwellings is 31% in Budapest, 39% in Debrecen, 52% in

Miskolc, 38% in Szeged, 42% in Pécs, 41% in Győr, 50% in Székesfehérvár and 60% in Dunaújváros (Census 2011).

There are totally 829 177 prefabricated concrete flats in Hungary of which 66,1%, 548 464 flats are in large-panel system buildings, the remaining 33,9% in other similar precast concrete buildings (Figure 1). The majority of these units were built between 1960-1980, only the 5,8% were built in the '90s. The last panel building was finished in 1993. Out of the total number of dwellings, the panel flats make up 18.9%, which is home to 1,741,577 people (17.5% of the total population) (Census 2011).

Figure 1. Number of flats in buildings of different material.



Total number of flats in Hungary (Census 2011): 4 390 302

1.2_"Panel" types in Hungary

The first buildings made with industrialized technology were built in 1954. The first form of mass housing was the block building. This contained half-storey high blocks, used mainly in the close proximity of the factory. Later the 1-storey high, 30 cm thick dross foam concrete blocks were used to construct 5-storey residential buildings.

The cast technology was typically used to create 10-storey high buildings. The load-bearing walls were made of dross foam. The planning mistakes significantly deteriorated the buildings' heat insulation and vapour barrier capability. In case of the tunnel-mould technology the wall and slab formwork are combined into a single system. Construction mistakes were often made mainly during the casting, for example blocked aggregates or using different type of concretes in a single structure which thus became heterogeneous. The above errors are significantly influenced the structural strength and thermal insulating ability.

During the seventies and the eighties the prefabricated sandwich panels became the dominant technology (Figure 2). In Hungary multiple "house factories" operated, mainly in bigger cities. Each one of these factories had its distinct solutions and improvements, thus it is difficult to talk about "panel buildings" in general. Most commonly, the panels were manufactured from high-strength gravel concrete with relatively weak reinforcement. The façade wall panels were first 25, later 30 cm thick and contained a 15 cm thick reinforced concrete inner plate, an 8 cm polystyrene thermal insulation and a 7 cm reinforced concrete cover plate.

The load carrying capacity of the structure is good, however the nodes are considered weak points of the technology where thermal brides and leaking frequently occurs (Dulácska 2013).

Within the boundaries of the Tabula Episcope Project a (TABULA) residential building typology was created. The primary question was to acquire information about how many building can be found in the country of different type. After developing the building types, model buildings were created which reflect the statistically average properties and specific technical parameters of the given type.

The goals of the project was to develop renewal packages for the types so the available savings and the renovation expenses may be determined. The 15 building types covers the entire domestic residential building stock and provides opportunity for deeper energetic analysis of the residential sector (NÉES).

Within the 15 types the type Nr 12, 13 and 14 contains the industrialized residential building stock. Type 12 describes the block buildings, Type 13 shows the panel buildings built between 1946-1980, while Type 14 describes the panel buildings built after 1981. Table 1. clearly shows that the Type 13 contains the biggest quantity of buildings and apartments, however it has the lowest rate of good condition flats. Most of the buildings in every type can be found in residential districts (NÉES).

Figure 2. Panel condominiums in Óbuda, Budapest (1986) (FORTE).

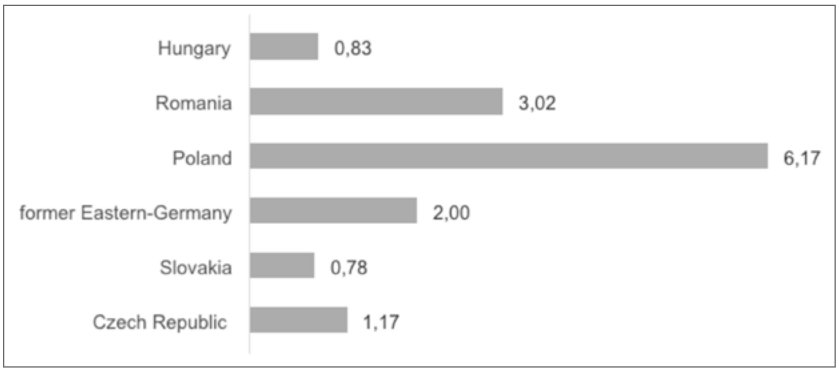
Table 1. Industrialized building types in the Hungarian building typology (NÉES).

Type	Construction date	Construction technology	Building quantity in Hungary (pc)	Apartment quantity in Hungary (pc)	Total area (m²)	Total area / building (m²)	Total Nr of apartments / building (pc)	Good condition	Satisfactory condition
12	not specified	middle or big blocks	8.345	185.256	11.346.937	1.360	22,2	68,30%	23,30%
13	1946-1980	panel	14.881	330.094	16.174.606	1.087	22,2	65,90%	22,10%
14	1981-	panel	7.271	187.428	9.877.417	1.358	25,7	73,50%	-

1.3_“Panels” in Central Europe

Other Eastern-European countries have even bigger stock of prefabricated buildings and flats than Hungary: In the Czech Republic there are 1.170.000 panel apartments where one third of the population lives. In Slovakia the number of panel flats is 778.000 representing 40% of the apartment units in the country (Talamon 2011). In the former Eastern-Germany more than 2 million such flats were built. In Poland there are 6.171.000 panel flats that is 49% of the stock (Novák 2007). In Romania, more than 3 million apartments can be found in prefabricated concrete buildings which is almost 40% of all dwellings (Figure 3) (EUSTAT).

Figure 3. Number of panel flats in central European countries (million flats).



1.4_Panel problem

The “panel problem” is a well know term to summarize the questions regarding the large number of panel buildings in Eastern-Europe.

The expected lifetime of the frame is 100 years, but the fenestration and other elements like plumbing and heating system are mostly aged. The high heating cost, which is partially caused by the high cost and losses of district heating is an important factor which is in Hungary closely connected to the buildings - the expensive heating is commonly paired with the panels. These systems are today obsolete and poorly efficient, but nearly all panel buildings are heated by them. On the other hand sandwich panels are commonly assembled with a 5-8 cm inner thermal insulation layer resulting a better U-value than a brick wall, however through the past 2-4 decades the inner layer deteriorated, which clearly increases the already high energy losses of the extensive amount of thermal bridges.

Other significant problems are the extremely high summer temperature, the overheating in winter accompanied with dry air (Talamon 2011).

As mentioned before whole new residential areas were built of panel buildings offering home to hundred-thousands of inhabitants. Besides dwelling units parks, walkways, public facilities were built to serve the needs of the residents. Through the years passed these buildings and green surfaces aged and the parks became mostly untended.

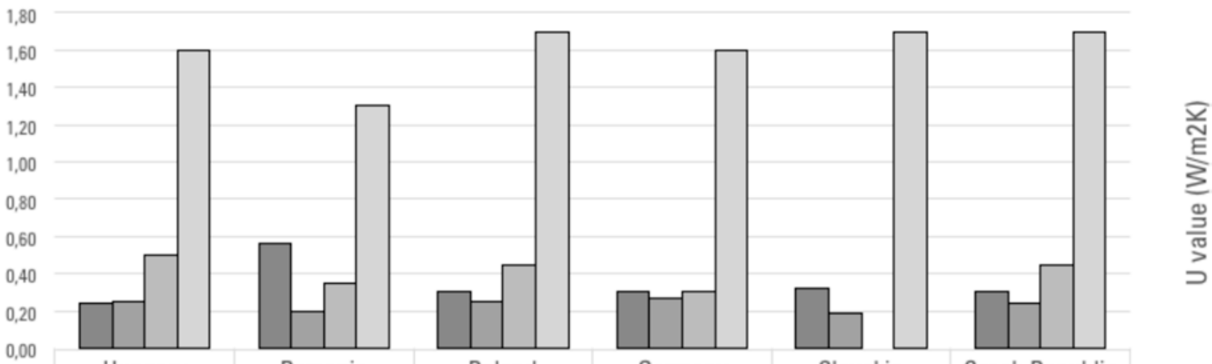
Because of the great number of apartments these buildings represent in the aforementioned countries, the demolition of the panels is not realistic solution (Hermelink 2006). Although the buildings were originally built for the middle class of the society, today more and more socially handicapped people leave there resulting financial and social problems, leading to the further declination of flat prices, accelerating the degradation process.

2_Retrofitting

2.1_Goals and directives

In 2009, European households were responsible for 68% of the total final energy use in buildings. According to European-scale surveys, the 48% of the Central-Eastern housing stock was built between 1960-1990, and only 17% was built after 1990. Investigation on the heating consumption of the existing stock shows that the largest energy saving potential is associated with the older building stock where in some cases buildings from the 1960s are worse than buildings from earlier decades. This is caused by the newer, thinner but uninsulated structures compared to the historical buildings greater structural size. The residential building stock renovated annually is only 1,3% in Hungary. The ratio is slightly bigger in Poland (2,5%) and in the Czech Republic (3,6%). (EBUM 2011)

The European Commission published the Europe 2020 Strategy in March 2010 in which the main objectives are to reduce the greenhouse gas emissions by 20%, or if possible by 30% compared to the 1990 level, furthermore to reach a 20% share of the renewable energy sources of the total energy consumption and to realize 20% energy saving (NÉES).



	Hungary	Romania	Poland	Germany	Slovakia	Czech Republic
	0,24	0,56	0,30	0,30	0,32	0,30
	0,25	0,20	0,25	0,27	0,19	0,24
	0,50	0,35	0,45	0,30		0,45
	1,60	1,30	1,70	1,60	1,70	1,70

Table 2. Demanded U value in case of different countries (DHUB).

The 2010/31/EU directive on the energy efficiency of buildings prescribes for the Member States that the near-zero demand is required to be applied in case of new buildings after 1st of January 2021, in case of public buildings from the 1st of January 2019. In addition the near-zero level must be taken into account when considering new constructions instead of the renovation of existing buildings. (NÉES)

The National Strategy on Building Energetics of Hungary prescribes by taking the National Energy Strategy 2030 into account that within the energy consumption of the buildings the primary energy savings are to reach the 49 PJ/year until 2020, and 111 PJ/year until 2030. In the boundaries of this prescription 380.000 prefabricated flats are planned to be retrofitted until 2020 by investing approximately 1,7 billion Euro for a complex retrofit of these buildings. (NÉES)

2.2_Retrofitting scenarios

Two demand levels were created for retrofitting to match the aforementioned European demands in Hungary:

The cost-optimal or standard refurbishment version means refurbishment considering the values of "TNM" (Ministerial Decree No. 40/2012. (VIII. 13.) on the establishment of energy characteristics of buildings) regulation coming into force on 1st January 2015. According to the regulation in case of substantial renovation the requirements of the newly built buildings are to be complied.

Since either the original structures, engineering systems and the numeric values of the requirement are different The technical solutions necessary to meet the requirements differ in each building type. (NÉES)

The near-zero or ambitional refurbishment version means refurbishment considering the same or better values prescribed in the aforementioned TNM regulation, besides at least 25% of the annual primary energy demand is to be created by renewable energy sources produced on or near site. The calculated values of possible retrofitting are summarized in Table 3.

Table 3. Primary Energy usage and retrofitting cost (NÉES).

Type	Construction date	Construction technology	Present state primary energy use kWh/m^2/a	Primary energy use in case of Cost optimal retrofitting kWh/m^2a	Primary energy saving kWh/m^2a	Estimated cost of modernization per heated area Euro/m^2
12	not specified	middle or big blocks	244	85	159	68
13	1946-1980	panel	218	84	134	61
14	1981-	panel	200	80	120	61

2.3_Past retrofittings in Hungary

Previous methods of panel retrofitting in Hungary. The energy rationalization in Hungary started already in the second half of the nineties by modernisation of the heating system. Thermostatic valves and heat cost allocators were installed first without any support from the state.

In 2001 the "Panel Program" was launched providing 1/3 non-refundable funds for thermo-modernization actions that were often completed with another supplementary 1/3 by the municipalities. Today there are great differences in the ratio of retrofitted panels between cities, because joining the program was depending on the decision of the cities: Győr, Székesfehérvár and Kaposvár already retrofitted most of their panel buildings however Budapest and Debrecen managed less than 20 % (Talamon 2011).

Most of the projects have reached 10-40% energy savings only, because until 2008 the support program did not motivate the owners for a complex retrofit or deep renovation. Because of the lack of monitoring the achieved savings are mostly rough estimations (Talamon 2011). Unlike other retrofitting programs in Europe (for example in Germany) the renewal mostly achieved

Figure 3. Top: earlier retrofitted panel (DSZ, PF).
Bottom: recently retrofitted panel (PF, NF).

building by building not considering the surrounding green areas, parks or public facilities which are commonly found in panel residential districts. The aesthetic upgrade is mainly contains only the colouring of the façade, although it is already a huge step forward compared to the monotone greyness of the concrete blocks. The first retrofitted buildings got simpler colouring (Figure 3), but nowadays more and more creative designs are made (Figure 4). Today, the 20% of the panels has full additional insulation and 50% is partly insulated (TABULA).

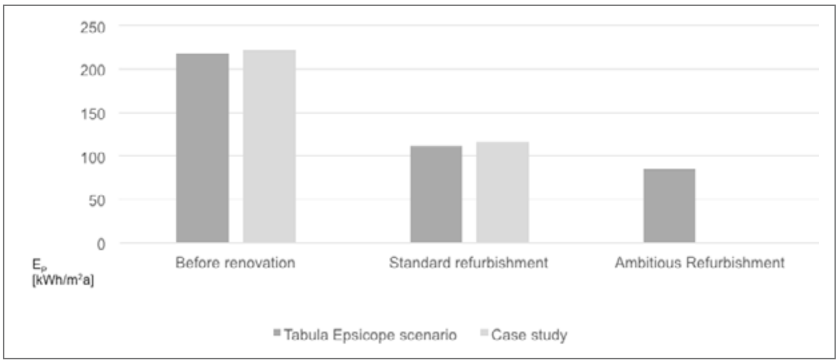
2.4_Case study of Hungarian panel retrofitting

Within the boundaries of the Green Investment Scheme (GIS) an extensive study was created by surveying the energy efficiency values of 70 refurbished panel buildings of Hungary between 2009 and 2012. The investigated buildings were not chosen according to the aforementioned types but as a collective representation of the prefabricated building stock of Hungary.

The following values were investigated: specific heat loss coefficients, specific final energy use of heating, specific primary energy use of heating, specific final energy use of domestic hot water, specific primary energy use of domestic hot water, total specific primary energy consumption, specific CO_2 consumption of the buildings. The specific heat loss coefficient represents the energetic quality of the building envelope. It gives a rough information about the insulation level of the building. Almost half of the analysed buildings are in Budapest, only 54% are in the countryside. The average construction year of the buildings is 1980. The earliest one was built in 1962, the last one in 1992 that was one before the last year of the panel construction industry. Among the projects there are all technologies represented among the industrialized technology. Approximately two thirds are panel buildings built before 1982 (typically worse insulation level), one sixth are panel buildings built after 1982 (typically better insulation level) and the remaining on sixth are other types (e.g. pre-cast concrete buildings, buildings made with medium-sized blocks) (Talamon 2011).

The results of the case study are compared to the values of the types of the TABULA project (Table 4). The calculated values of the case study show the average values of pre-refurbishment primary energy demands of the TABULA numbers – proving that the buildings of the case study were chosen well as representation. The average primary energy demand (total of the heating and domestic hot water demands) before refurbishment was 221 kWh/m^{2}a. After renovation of the building stock, the calculated primary energy demand was 116 kWh/m^{2}a, which is only slightly higher than the demanded 112 kWh/m^{2}a of the TABULA projects' standard refurbishment values. The average 83 kWh/m^{2}a primary energy demand value of the ambitious refurbishment scenario was approached in neither refurbishment (Talamon 2016).

Table 4. Total primary energy demand for heating and domestic hot water [kWh/(m^{2}a)].



3_Summary

In case of prefabricated residential buildings the near-zero energy demands could be reached by using the materials and retrofitting techniques described in the TABULA and the National Building Energy Strategy. However, the previous refurbishments made between 2008-2015 mostly do not reach this level because on one hand the residents of the houses are not motivated to aim for near-zero energy levels. On the other hand the planning mistakes, the materials used and the lack of full financial support the reached energy efficiency values only closing on the demanded values of the standard (cost optimal) refurbishment, which is not equivalent to the near-zero demands. Without greater consideration of the aforementioned, the near-zero demands will not be reached. Moreover considering the wider environment in the panel residential area would be desirable. Modernizing the public facilities and parks surrounding the buildings would add to the value of the flats and create a pleasant environment.

4_Acknowledgments

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THE ROLE OF PRODUCTION SPACES IN A POST-CARBON VISION

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Keywords
factory
city
third industrial revolution
new production spaces
digitalization
industrialization

Abstract

Heading to a post-carbon future requires a profound redefinition of the imaginary of the city and its places. The contemporary city is the result of a continuous override of spaces that are no more useful and abandoned, but today a post-carbon vision must be able to define how to use these spaces discarded by economic and political flows of our cities. Industrial districts, warehouses, factories, work spaces disseminated on urban conglomerates, are the picture of what is being left behind by our carbon based culture.
A post-carbon city has an absolute need to define a new relationship between factory (production) and the city itself.
The emerging of digital fabrication technologies, DIY online communities, local cluster and new production processes are the key points to analyse the changing way of production. Different examples from GMDC of New York, The Green Garage in Detroit, the Silicon Roundabout in London or the Fab Labs scattered all over the world are some of the realities that seek to integrate the reuse of urban production spaces with renewable energy and activities that create social, economic and technological values in the districts in which they are inserted.
The analysis covers the evolution of production by studying its characteristics at the urban scale, defining what is the contemporary production space and how a manufacturing processes is evolving in relation with the environment; in order to start regeneration policies that create value and became engines of real practices and experiments towards the city that we want to build.

1_Text

Today, there is a broad consensus that the world in which we are projected will be radically different from what we have known in the past. In our history there is no historical period comparable to the era that humanity is going to address. The various revolutions that have marked our history didn't possess the same charge of dangers and possibilities but also they didn't have the same amount of simultaneous and radical changes, converging one towards the other, for which we are called to respond now.
The climate change and the emergence of a global growth increasingly unsustainable in terms of population and in terms of exploitation and consumption of natural resources are creating a widespread pollution, driven by an economic output that is subject to distorted parameters that prevent us to see the destructive consequences in pursuing this attitude.
This conflicted reality and its stratification find in the city their images and representations. Since the beginning of the Industrial Revolution the city was the theatre and the space for the experimentation of the economic stimulus, of the scientific and technical process and the belief in progress. The city of the nineteenth and twentieth century was casted and built around the industrial process, accepting the dogmas and shaping itself around this new dominant sphere. Factories become the place par excellence for human life by absorbing the daily life with working shifts that alternate themselves day and night without stopping. Roads increase in size in order to support a new structure for transportation, the only element of distinction between the

productive space and residential complexes, new dormitory suburbs arise denouncing a complete lack of services and new materials and prefabrication process became fundamental for rapid construction and urban development. The industrial city has assumed strongly different characters from the historical city. This is evident from the human point of view where there is a clear change of spatial perception of the surroundings as imaginary and sensations, but also from the point of view of city planning with an urban fabric that counterpose the organicity of historic urban settlement with a rational allotment according to specific guidelines, which often collide with the main transport routes. As for the historical city, the industrial fabric assumes internally different contradictions, overlaps and stratifications that are the necessary consequence of a continuous evolution from proto-industry of the early nineteenth century (1) to the full mechanization of mid-twentieth century (2).

Unlike its counterpart, the mechanized city never developed a process, a "digestive system", necessary for the assimilation of the changes, especially at the urban scale: the time. The great progress that humanity has embraced with a growing enthusiasm, because it finally broke the chains that bound man to natural processes, was the overthrow by the industrial process of the conception of time and space. They were cancelled by the introduction of new forms of energy and of a technological process that makes possible communications and travels faster and faster

In this way the time of man business become detached from the time that marked the natural processes, defining one of the causes of climate and energy issues. We are no longer able to understand the consequences of our actions compared to the time that the environment needs to assimilate them, due to the lacking of a direct perception of these actions and thanks to persevering in the use of an economic process that doesn't take into account the cost inflicted on the planet. Proceeding in this direction is impossible to counter the dominant attitude. This approach is also reflected in the relationship with the industrial city, where new buildings, warehouses and roads join a steady increase number of empty spaces, abandoned at the end of their vital purpose, crushed by economic interests, constantly changing, and not re-included in the design process of the city.

Sometimes, the market economy has been so influential to undermine entire cities, bringing them almost to the disappearance. The case of Detroit is a good example of how a city defined by an industrial monoculture, following a situation of severe crisis, could literally disappear with a reduction of the population of 1 million (3) inhabitants since the early sixties of the twentieth century, with 36% of homes abandoned or foreclosed and an administration that doesn't have the resources to maintain the public space (4).A reality that has entered a deep crisis, threatening sometimes even to disappear (5) when the economic and social system which was developed has reached the stage of decline.

Inside the contemporary city heading towards a post-carbon future requires a profound redefinition of the imaginary of the city and its places. The projection of the values of a digitized manufacturing towards urban space can become the vehicle for a redevelopment of the heritage of an industrial and carbon culture.

A vision for a post carbon city must be able to define how to use the spaces discarded, abandoned by economic and political flows, redefining the relationship between the production space and the city itself. Different examples from GMDC of New York, The Green Garage in Detroit, the Silicon Roundabout in London or the FabLab movement, scattered all over the world, are some of the realities that seek to integrate the reuse of urban spaces for production with renewable energy and activities leading social, economic and technological value to the districts in which they are inserted.
The contemporary city, a habitat for more than 54% (6) of the world's population is the result of a continues override that like never before have to face a discussion about what to do with the "waste" it produces. Often the type of building in question does not develop a particularly important or valuable characteristics: they are standardized buildings, warehouses, abandoned offices, which come together in a multitude of generic spaces (7) within our cities. Private and public action may be able to use these scraps thanks to a renewed relationship between the space of production and the city itself.
Private actions such as the one made by GreenPoint Manufacturing and Design Center, a non-profit industrial developer in the city of New York has allowed the redevelopment of five industrial buildings, the relocation of production space for small and medium-sized companies, where they can find the habitat for developing their business and the use of LEED certification as a strategy for energy development.
Especially the building at 1102 of Atlantic Avenue, in Brooklyn, has provided space to 14 different business and 76 employees with an average salary of around 47,000 $, which is 58% higher than both the food and retail sector average salaries in New York City(8). Additionally, 1102 Atlantic Avenue have a negligible carbon footprint and stand as a model for green development in a traditionally industrial neighbourhood. This project includes a 58kW solar array on the roof, and is expected to achieve LEED Silver Certification for its efforts in reducing waste and minimizing harmful emissions, a welcome departure from the industry of the past (9).
In Detroit, Green Garage, a business incubator following strategies triple-bottom line, has included in the design for the renovation of its spaces the construction of a hybrid energy system for heating and cooling that Integrates passive and highly efficient active systems to create an ultra-efficient HVAC system that integrates mechanical ventilation components with a moisture control to create an healthy system, a building process that foresaw the reuse 90% of all non-toxic deconstructed materials and the integration of a new insulation of the existing building to lower the regime of consumption to at least at 70% of the previous state (10).
In addition, the re-use of 'buildings located at the 4444 in Second Avenue led to the improvement of the urban environment with the creation of the Green Alley, designed and builted by volunteers and the beginning of a new project for the construction of a passive hotel in an abandoned residential building named "El Moore" built in 1898, in West Alexandrine Street (11).
These two buildings are examples of how abandoned industrial buildings thanks to a private process of re-appropriation can become engines for local development and re-appropriation by the community of the spaces in which

the economic system in crisis not see value, transforming them into new production areas according to an upgraded sustainable vision.
But not only the architectural space has the opportunity, through proper design, to return to be part of the urban process, but the same production process undergoes to a transformation that resizes the necessary space, bringing new interest to small urban spaces abandoned within the city.
Realities like Shapeways, which opened in 2012 its first "Factory of the Future" on the suburbs of New York, possess only a 10% of its 2,400 m^2 as a space dedicated to the production, the remaining space is dedicated to its employees, involved in the optimization of 3D projects and products digitized by users and subsequently made by additive printing (12).
The Factory space assumes different connotations from the imaginary of the twentieth century, not the biggest polluting and oversized production plants, but spaces that through the use of digital platform become defined like hybrid places merging workspace, public space and space for the community.
This is the method of the FabLab movement, that has spread around the world and where services of digital fabrication and other semi-automatic machine give a chance to individual users to carry out their projects.
From the compartmentalized characteristics of the places belonging to a Fordist reality where containers defined the spatial and social reality inside them, emerges a reality where industry, start-up and incubator, company space and public urban realm coincide. In this really was born the Third Industrial Revolution of Jeremy Rifkin, the revolution of the lateral power (13), where a mass society made up of self-employed, micro-entrepreneurs, inventors, makers, constitutes virtual relationships within the world of e-commerce.
At the urban level, the ability to use the industrial space for new production purposes has realized, in the cities of London and Barcelona, the requalification of ample urban sectors that were characterized by low levels of spatial quality. The London case appears around the Old Roundabout, renamed Silicon Roundabout is opposed to the intervention in the district of Sant Marti in Barcelona since the first has spread by small private projects on the same territory while the second is a result of the action of the municipality with the granting of loans by the European Union.
The Silicon Roundabout, also known as East London Tech City is a technology cluster located in the central and east London. It occupies widely the East End of London between Old Street and the Olympic Park in Stratford, with a primary focus in the area of Shoreditch. The Silicon Roundabout is the third largest cluster of technology start-ups after San Francisco and New York, and it was initially developed without government support, around the Old Street Roundabout.
This suburb and degraded area in north of the city of London, historically had rents much lower than the rest of the city, mainly due to the lack of transport infrastructure that would allow quick movements. The urban fabric consists of warehouses and abandoned buildings of industrial character and a public urban degraded environment. Start-ups were encouraged to settle in the area by its low rents produced by the recession of 2008-2009, which caused the closure of many architecture firms, design and artists studios who had

Figure 1. Building property of GreenPoint Manufacturing and Design Center in 1102 Atlantic Avenue.

settled in the area, further decreasing rental rates. Ironically in 2009 the Old Street was not even served by fiber optic cables, while a few blocks away, in the City of London, where rents were much higher was already in place an extensive infrastructure. In 2010, Prime Minister David Cameron has announced a plan to accelerate the growth of the clusters in the area bringing a frontline interest of the municipalities and the state. Many were against this intervention that led to a high increase in rents that eliminates the smaller companies.
After the recognition of the importance of the area, the strategic action of greater impact for the community, was the creation of an integrated proposal for the management of roads flows with an extensive implementation of pedestrian and cycle facing, reprogramming the public urban spaces that were inadequate. The municipality also build a structure called "Super City connected" in order to link from a digital point of view all the buildings and the realities that define its territory (14).

The 22@ district is also known as the District of innovation. This is the name given to the district for corporate business in the former industrial area of Ploblenou, in Sant Marti, nicknamed "The Catalan Manchester" in the nineteenth century. The purpose of the project is to convert this industrial area into a technology and innovation district for the city, increasing and requalifying the green and the residential spaces. The project, still under construction, is part of one of the largest urban renewal programs in Europe, which began in 2000. The plan covers 115 blocks and 198,26 hectares. Instead of applying a model of territorial specialization, the city of Barcelona has developed a mixed model that promotes social cohesion and a urban and economic development in balanced with a sustainable context. The activities of the cluster co-exist with the traditional activities of the area by creating a rich and diversified environment. It involves the use of 10% of the land for public use (145,000 m^2) with the determination of structures that include training, research and the promotion of new technologies. These structures promote synergy with universities, technological and research centers and production activities in the area. At the same time these facilities help to alleviate the shortage of community facilities in the district.

The public space, as a supporting element for the urban fabric, for relationships and activities, is one of the guidelines for the project configuration. The structure of green spaces was proposed following a sequence of steps in which wide open spaces will gradually extend to the squares and the smaller streets and houses, becoming a real meeting place for residents. The new infrastructure plan provides an investment of over 180 million € and allows the realization of a modern network of energy, telecommunications, district heating and waste collection. The design of these new networks gives priority to energy efficiency and the responsible management of natural resources (15). The industrial cases analysed thrive into mixed-use neighbourhoods with the reuse of abandoned factories for the emerging producing class. This action preserves the existing housing stock, demonstrating the adaptability of industrial buildings and highlights their suitability for the production of the XXI century.
With the growing ranks of designers and makers who attempt to scale their products to the market, through the tools of open source and crowdsourcing platforms, a small flexible space and a shared knowledge on how to scale production will become more important and will be the guide lines for the definition of the evolution of urban space.
In an urban policy that seeks to stop the use of land in the interior and on the edge, rethink the abandoned spaces or disused takes on a double meaning: bring to light a historical stratification expanding it with additional overwrite and restore urban infrastructure already existing. Reflect on urban production is not only a way to establish trends of the future industrialization, but is mainly a way to reflect on our city. Analyse the tales, re-establish contact, a story, a stratification between the built and urban life.

The venture towards a post-carbon means understanding how trends and capital flows can be conveyed in order to implement strategies that move in this direction. The city as we know it's the image of the structure of our society and it's essential to understand how the actors that take part to it are moving. While the economic case for the return of urban production are mature, spatial strategies to support production are scarce or non existent. In the cities, the production claims the urban field, generates innovation, serves as a strong economic multiplier and provide an economic resilience. The addition of industrial typologies in mixed-use areas therefore increases the quality of the public sector.
If we evaluate the macro-economic factors that allow the return of manufacturing in western cities, the architecture has an opportunity to fully revise the manner in which the production is embedded within the fabric of the city, analysing and aligning an economic process with the needs for the future.

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Abstract

The evolution city into Post-Carbon City has resulted in the disuse of large industrial areas. Some of these are now, places of human activities incompatible with the needs of society and environmental emergencies. The urban planning and the mobility system of these highly central areas, are necessary for having a quality of life and economic activities linked to: sustainable development, preservation of the identity of local communities and relationship with the rural area. An urban regeneration case eligible as a excellent example is: the Ruhr.

This German region, was object of an exemplary structural upgrading at regional scale of the territorial system. Which has averted a looming environmental damage caused by over a century of industrial production. The design was procedural and did not use a general masterplan, but a strategy composed by seven individual plans certainly achievable.

The managing bodies of the intervention on a regional scale, were created from the specificity of the process of transformation and crisis of this territory. Obtained the most appropriate means of evaluation by following a careful analysis of deficit and potential aspect for each project. Creating, in this way, a solid foundation for a lasting economic, environmental and social renew.

These strategies will be actualized in: the EmscherPark. The element of the park has inside: tertiary, commercial and technological innovation. Becoming also the main source of employment and income for the new image of the region. This regeneration method, regards the creation of unreleased management tools of the territory.

THE RUHR, VIRTUOUS MODEL OF UPGRADING?

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1_Introduction

The saturation of the soils does not allow to build new infrastructure, therefore became an essential prerogative learning how to interpret the urban voids. Since they are often a link between the old town centre and the new expansions. Their centrality makes them attractive places for new urban transformation. Those that we consider *voids are very extensive but also full of potential, so their disposal allows to propose new configurations precisely in parts of the city to now devoid of "margins of flexibility". The disposal is also considerable as a crisis of function, but does not affect the central role, now acquired, by the places in which it occurs, it tends to accentuate, giving to it a new meaning* (1).

The former main coal mining centre of the European continent has now changed its nature; the Ruhr area is well known for about fifteen years for a regional reorganization to 360 degrees (implemented from 1990 until the beginning of 2000), which begged the looming environmental damage caused by over a century of industrial evolution. This redevelopment was then extend to social, political and economic ambit.

The aim that proposes this research paper is to analyse the main effects and results that has pursued the environmental and economic conversion of the Ruhrgebiet. The purpose, is to understand if the intentions that moved the entire operation of the structural change of the Ruhr could be translated into a real successful and used as a model across the world. Often cited as a role

model and apply in areas of degradation of physical space and social phenomena as a result of industrial disposal.
Has this intervention program really achieved sustained success over time? Can it be considered the starting point for the certification of the Post-Carbon City?

2_Background

The Ruhr, the most extended basin mineral of Europe, is located inside one of the most populated federal states of Germany, the North Rhine-Westphalia. Crossed by the rivers Ruhr and the Emscher. Thanks to the mineral wealth of the subsoil, since 1850 the Ruhrgebiet began a long period of industrialization made up of light and shadow.
First, the industrialization cause a deep changing of the landscape. In Fact, before the nineteenth century there were no permanent surface structures for the coal mining, because the extraction did not happened during the whole year. Successively, *with the advent of the steam engine they started to build permanent structures, the mining activity grew and the structures on the surface became composed of extraction towers, engine rooms and laboratory for washing and preparing the coal* (2). The arrangement was structured in order to limit the movement of coal and workers in relation to the main roads. Furthermore, at the beginning of the twentieth century, the steam engine was replaced by the electric motor, this allowed a greater freedom to organize the volumes of the area. The greatest influence on the architecture of the region, came by the industrialists class. Which, with the bourgeois revolution of 1848, began to express their status through the factories. That's the reason why, the Ruhr boasts buildings worthy of being preserved and reused.
Another fundamental transformation happened in the society. Miners and farmers turned into workers and technicians. During the 1850 the inhabitants of the Ruhr were still mainly with an agricultural vocation, but already in 1900, they could be consider the workers of the largest industrial centre of the continent. In little more than a century, the territory underwent a profound transformation: in an area of 4,432 square kilometres, the inhabitants went from about 300,000 in 1820 to 5.7 million in 1965; the existing mines arrived, in until the 1956, to extract about 124 million tons of coal per year. The Ruhrgebiet, become fundamental for the sustenance of the future Europe, that through its concession, one time, Germany extinguished economical debts.

Figure 1. Foundry in Oberhausen.

Figure 2. Duisburg Bruckhausen.

The problem of the deterioration of the ecological assets in Europe, rose to national political issue in the early 60s. The reuse of industrial areas began with the first signs of de-industrialization, adopting three types of intervention: renewal, revitalization, recovery. In 1970, with the crisis of the coal mining activity, each spot, was gradually abandoned and the other sectors related to it have been greatly reduced. In the Ruhr, it has recorded the highest percentage of industrial land and disused mining in East Germany. In the land of the industrial primary (the chimney higher, the deepest mine, the mill more specialized) was spreading alcoholism, drugs, depression (3).
In the eighties, with the recognition of part of the industrial heritage as Heritage of Humanity of Unesco, it has been developed a program of revitalization of the Ruhr coal basin; integrated with important interventions of Environmental and Economic Planning.

3_The strategy

Defined as a structural upgrading on a regional scale in a territorial system, the transformation has gone through several levels: economic, social and environmental. *Heal the damage was most impelling prerequisite to regenerate the area, due to the fact that the landscape is characterize by: vast industrial plants decommissioned and reclaimed, toxic dumps, railway yards and abandoned slag heaps coal, as well as workers villages emerged chaotically up to fill every space and then abandoned* (4).
The great process of productive reconversion and environmental enhancement was implemented through a policy of regional planning conducted by appropriate institutional bodies (such as the KVR and IBA).
The role of the IBA as a "moderator regional" has produced important results, showing that *the public power is capable of governing the transformation of the territory. A specific reference institution conducive to dialogue between: industry, trade unions, social groups and local authorities; by supporting organization and quick decision-making. This experience enhances the role of the Public in any operation to revitalize the method of working and produce* (5).
The task was realized through:

- Policies of strict protection of the free spaces remaining
- By releasing and recapturing the new nature areas
- Keeping the most significant fabrics
- Thanks to a mixitè of residential and productive zones with green areas
- A system of walking and cycling routes by recovering several water channels and rail routes.

The main intention was to reach a new centrality of an entire region, all projects have been strictly aimed to give a solid foundation for a profound economic, ecological and social development of the Ruhrgebiet. All the specifics action plans redacted had as a starting point: the strengthen the weak spots in the region. Furthermore, these have been developed, with more simplified and effective tools to "govern" the increasingly complex economic and social processes on the territorial structures.
The seven main items, on the basis of which it was possible to build a new post-industrial landscape of the Ruhrgebiet were:

- *the landscape park of the Emscher*,
- *the ecological reorganization of the hydrological system of the Emscher*,
- *the recovery of the Rhein-Herne canal as recreational space*,
- *industrial understood as historical monuments*, "The route of industry"
- *new employment thanks to the park*,
- *housing construction and development of the neighbourhoods (innovative forms of housing)*,
- *new proposals for social and cultural event*, "The route of culture" (6).

Each element, is strictly combined with the nature, symbol of land reclamation and revival for the region; which is integrated to the signs left by man. For example, the disused railway lines that trace the paths within the park.

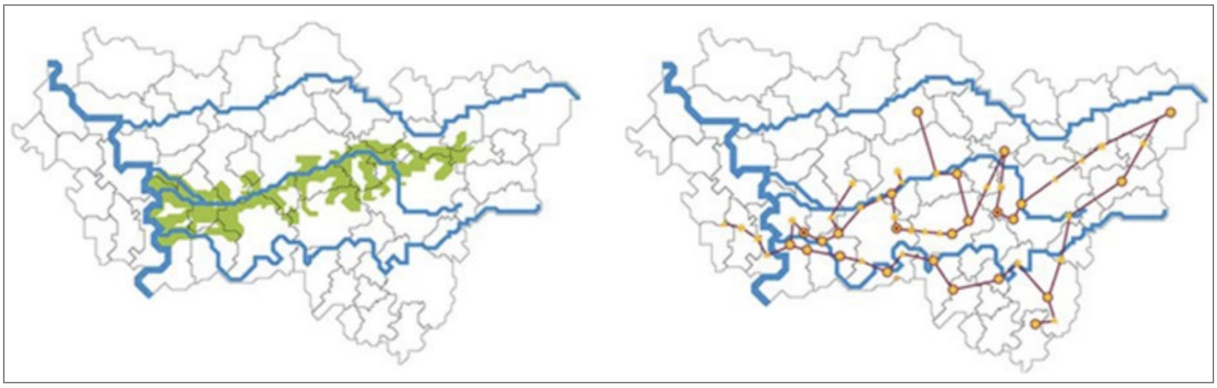


Figure 3. The Emscher Park on the left and the Route of Industry and Culture on the right.

4_Main Characters and Needs

The IBA (Internationale Bauausstellung Emscher Park) is the company set up specially in 1988 by the government of the RSW LAND (Land of North Rhine-Westphalia) to accelerate the transformation of former industrial areas, then disbanded at the end of conversion operation planning. It was composed of economists, environmental experts, trade unions and political and a coordination committee referring to the minister of urban and transport. The representatives of the region, are joined those of the main local municipalities, professional associations and dozens of individual professionals interested in the project. Configured as a consultancy, this company has played the role of concerted and participatory structure for addressing social groups, environmentalists, designers and entrepreneurs sincerely interested in thinking about this common goal of the regional requalification.

The IBA, operates over an area of 800 square kilometres, following the River Emscher, counting two million inhabitants and seventeen cities. Furthermore, it has structured the entire operation based on individual projects of certain actuation and not through a general masterplan. All plans have been defined through an analysis of the deficits of the region and each structure was analysed according to very specific requirements; that would have checked the possibility of reuse.

By proposing itself as a public cooperation, the IBA has not affected the traditional planning tools. *It set itself as a catalyst and activator of the ordinary and extraordinary resources. Furthermore, it was as well able to implement any local activity by using, according to each case, ordinary urban instruments*

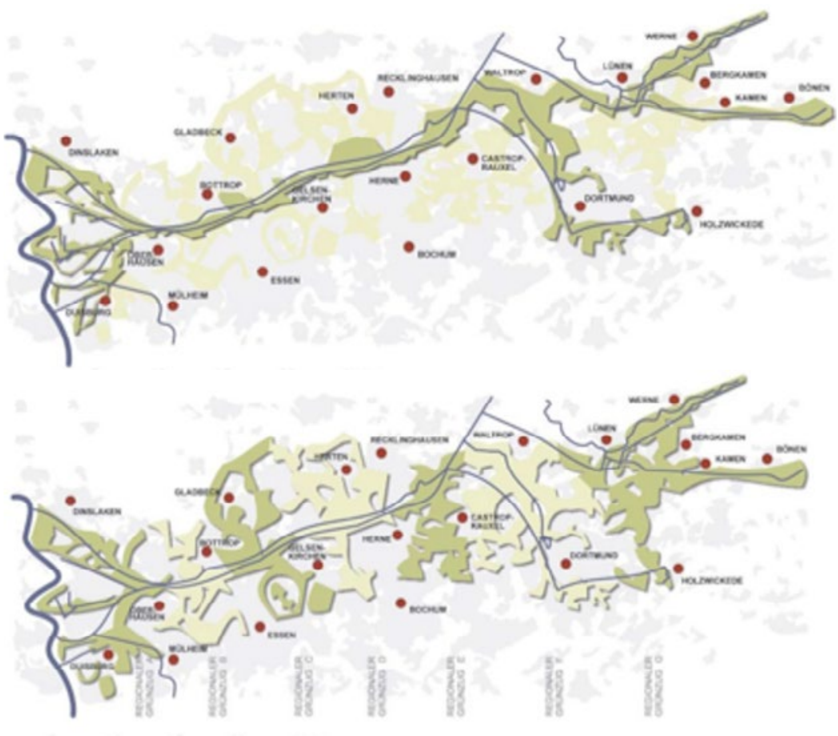


Figure 4. The IBA Emscher Park, unifying the East-West direction, and the North-South Grunzuge of the KVR.

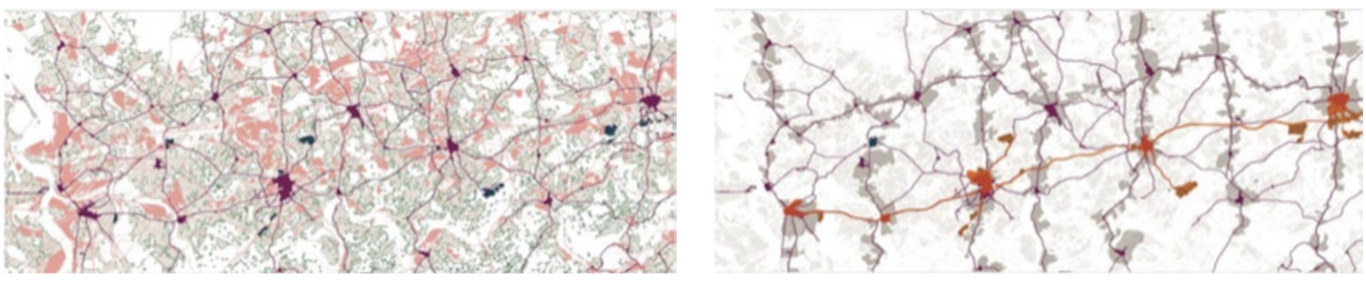
required. That king of strategy has enabled to develop a new method to deal with complex issues, such as the structural upgrading of a large region of ancient industrialization, now in crisis (7). Consequently, to this intention of simplicity and speed of implementation have been welcomed these willingness to search for new innovative methods.

Fundamental was the ability and the perseverance to direct private participation also to projects less economically profitable, but essential for the environment. In fact, one of the most surprising outcomes that this great initiative has managed to create, was the formation of a new image of the Ruhr. It becomes a region dynamic, which was able to create potential from its problems. By acting locally, it was clear how to turn their deficit in resources; from the specific process of transformation and crisis of the territory and by using the decline of the heavy industry, as the basis of a solid foundation ecological economic renewal.

5_Urban, social requalification and rural modernization

As Petra Potz says, one of the innovations in the strategy of the IBA was represented by the participation of social forces and citizens interested in the projects. Before and during the different stages of the process, *were directly involved in decision-making the citizens, through the creation of forums for*

Figure 5. The left image is showing in purple the principal cities of the Rurhgebiet, in pink all the industrial areas.
The right image is showing in orange main road axis from east to west, in purple the secondary road from North to South from and in grey the worker villages (Siedlungen).



discussion and learning, moments of public discussion and communication of how activities were going on (8). Indeed, by enabling national and international competitions, was possible to create a multidisciplinary teams, responsible for: architectural, urban planning and ecological aspects. Tue to search for the most competent person for each position work, the direct allocation method was override.

The seven key themes of the operation were defined through phases of consultation between the public and private actors (administrations and local professionals) involved in the requalification. *During the projects evaluations, was fundamental the quality of the social ambit, thanks to the attention to the needs of vulnerable groups and the activation of procedures of involvement and participation of the inhabitants* (9). The IBA, through the renovation of the residential areas, took care of the lower class, ignored by the market and bearers of particular questions.

Interviews and questionnaires were conductive during the rearrangement of the most important Siedlungen (residential complexes built during the Weimar period on the outskirts of several German cities). There was ask the opinion of the residents which voted the functions needed in each neighbourhood. The importance given to the community, is shown by how much this ecological, social and economic requalification, went mainly through the redevelopment of public spaces.

5.1_The Emscher Park

The new meaning of the park is the main innovation. It is propose a new typology: "the park of services". An area that includes various activities surrounded by nature, in which the building and recreation areas, are new relations of contiguity; and the progressive thinning out of the built creates a kind of filter between the compact city and open to the nature.

The plan for the Emscher Park project, aims to incorporate and supervise the steps of the gradual renewal operation of the whole region. In order to coordinate and keep under constant review the various interactions and reactions triggered by the collaboration between the numerous social partners involved. A Landscape Park, which covers an area of about 320 sq km, representing more than a third of the whole Ruhr area (800 sq km)and receives 23 million of tourists per year.

The park is set up as a sequence of open spaces dedicated to the collective practices, in which are included walking trails, bike paths, areas for recreation and museums made in abandoned industrial buildings. A landscape no longer accrue due to the abandonment and pollution, now is able to call people by the virtue of its public function. Extended and particular spaces, in which leisure and recreational activities can be configured to suit the populations needs, generating unpublished profiles (10).

Elena Marchigiani argues, how fundamental is the central role assigned to the quality of the public space, intended as a set of places of everyday life of a community. In addition, the creation of this technological park has succeeded in attracting the interest of young creative entrepreneurs, that have played a pioneering role in this regard, and the investors from the rest of Germany and abroad.

At the same time, the restoration of the great "cathedrals of work" was conceived as an opportunity to start training courses on building restoration, while their management offers new employment opportunities to cope with the high levels of unemployment. A consequence to be reckoned with in the rehabilitation of old steel plants and coal mining, has been the possibility to limit the consumption of soil. The reintroduction of these brownfield sites in the market has allowed at least in part to make up for the demand for new building soils (12).

6_Comparison between authors

This kind of approach to the land management is, according to many authors, applicable in other post-industrial contexts. For example, according to the opinion of Petra Potz, *the experience of IBA can be "exported" to other realities with regard to its mobilizing effect. A complex catalogue of structural works, which for the network that form, can change and transform the conditions of an area in crisis. This is a different form of approach that goes beyond the parochialism and the micro-restoration of individual municipalities* (15).
The mode of action, not through one big masterplan for the region (difficult to achieve), but through different specimens projects of certain actuation, is, according to Gianni Pattena, an operative example of a complex treatment on the territorial scale. *Almost as a laboratory, where tools were applied, are now ready to be used elsewhere in across Europe; for large dismissed industrial zones* (16).
This opinion is shared also by Fabio Minucci, who says that *the process elaborated for the Ruhr, is a new way of facing the problems of planning policy and its implementation. Extremely innovative, of considerable interest to other realities in rapid transformation* (17). The Ruhrgebiet, as stated by Klaus R. Kunzmann, can be considered *space of inspiration. The projects of IBA are far from normal construction in urban areas, are considered particularly creative projects, models that show the way for future challenges. The IBA Emscher Park is an enormous wealth of ideas for the modernization of neglected urban spaces, and has led other cities and regions to copy their model and to deal with the help of the imported model in order to tackle the various challenges of urban development in an innovative manner* (18).
The IBA's project could be brought around Europe as an example of strategy for urban construction for difficult places object of political controversy. *A brand, that carries out projects not feasible under "normal" conditions* (19). In the end, there are two voices that criticize those who claim that the experience of IBA is exportable.
The first is Klaus R. Kunzmann, who points out that certainly, the IBA is now in the international history of urban requalification, but it is not transferable. *In no other old industrial region of the world could find much public support for a project as "subversive", indicating a future that far without worrying about immediate commercial success* (20). This was especially the vision and guidelines, organizational and communicative of its "inventor" and director Karl Ganser. Just, Karl Ganser, *suggests a cautious attitude about the possibility to generalize the experience of IBA Emscher Park, saying that each region has*

a different economic and legal methodologies. For this reason each one must find a specific transformation strategy of its territory (21). Ganser, argues that *the experience of IBA Emscher Park is only possible to draw a high degree of interest in the ecological and cultural scenery, especially when the employment situation is particularly depressed and there's the need to invest extra resources and forces, through an alternative approach to planning* (22).

7_Conclusion

Has this intervention program really achieved sustained success over time? Can it be considered the starting point for the certification of the Post-Carbon City?

The key elements worthy of esteem are the time and the countless resources, made available in order to strengthen the potential already present in the territory. Thanks to that, the great results of the qualification process have been able to emerge above all later from the intervention.
Alcoholism and unemployment that dominated the region, have been replaced by less than 23 million tourists per year. Essen was the Capital of Culture in 2010, becoming the first case of industrial heritage to whom was given that title. Thanks to a total of fifty-two installations (factories and Siedlungen) that compose the regional touristic "Route of Industry", with 400 km of pedestrian roads and 730 km of bicycle path. The "Road of Culture", which runs parallel to the industrial, offer panoramic stations and art installations, each year increasing thanks to the numerous competitions and festivals, organized by the region. David Chipperfield, Norman Foster, Herzog & de Meuron, Rem Koolhaas and SANAA, are some of the famous personalities intervened in order to provide new life to the sites industrial developments.

The change is a reality experienced and new identity at the same time, which nowadays characterize, not only the main five cities of the Ruhr (Duisburg, Oberhausen, Essen, Bochum and Dortmund); but also in the other more than 50 centers of the region. International large events like "the Ruhrtriennale" and new sustainable strategies are still characterizing the region since its requalification (1990-2000). Essen, emphasizes the quality of work done by the masterplan strategies, being elected from the EU as the "European Green Capital 2017". Furthermore, since 2003, had been redacted two programs: "The Concept Ruhr" and "The City Regional contract", as a joint platform for sustainable urban and regional development.
With the goal of increase the sustainable management of the whole region by the 2020 and the 2030.

It is believed, that with the IBA Emscher Park, was born the idea of preservation of the culture industry. The IBA is mentioned when it comes to conservation and sustainable revitalization of the industrial landscape in ruins. Many of these projects have opened new horizons. Were design, manufactured and widely announced, with a great use of intellectual and financial resources. In addition, it will attract the support even from the last skeptics. All this, shows how one of the best results achieved by the IBA, has been the ability to imagine its future on a larger scale. The IBA had the willpower to direct public and private efforts to a structural change in the region that would manifest its results only in a distant future (more than ten years).

Experts do not always have found totally positive results: for example, there was not created the employment that were expected, or not always participatory processes in the management of the territorial government have been satisfying. It is nonetheless evident, however, that the positive result far outweigh the negative ones. In fact, is hardly point out in other European regions such operations that have been able to create an ecological renaissance of the land, a new shared image among its inhabitants and an ability to manage a regional transformation with new planning instruments most Democrats and wide as possible.

The highlights, that defining more precisely the objectives of the entire operation, are:

The German public opinion has always been sensitive to environmental issues: for example the German Green faction is the strongest in Europe. Consequently, the inhabitants of the Ruhr have been involved in major decisions about the ecological reorganization of the region, taking part in public discussions and sometimes to the management of the places retrained (like the settlements). All political parties have shown their support for a territorial transformation and a renewed image of the Ruhr, which played a crucial role for the achievement of the project. Another fundamental condition, to be taken into account, is the wide availability of money that made this possible. Certainly, the public financial commitment was crucial to allow the start of the process of productive reconversion and environmental enhancement. As claimed by Elena Marchigiani, *the initial predominance of public funding has allowed to make the site once occupied by the industries, again attractive to private investors* (23).

The total cost of the redevelopment was 563 million euro, including public funds (state of North Rhine - Westphalia), private investment and funds from the European Union. This sizeable amount of funds makes it clear that the so-called "operation Ruhr" is not applicable everywhere. The Ruhrgebiet, despite the crisis that followed the disposal of mines, still had funds able to realize such an intervention, since it was in the past the Major European steel and mining centre. Today would hardly be possible to repeat a similar intervention (for example, in Italy) with the systemic crisis that has hit Europe and beyond. Another surprising aspect is the fact that this operation took place during and following the political upheavals that took place in Germany during the late eighties, which is the German Reunification. Would be interesting to investigate how it was possible to make an operation of high economic challenges in a difficult period of restructuring of state institutions. Also, it has shown how it was possible to direct a large amount of money to the Ruhr (Federal Republic of Germany) in a time when the economic recovery of the so-called East Germany was necessary.

In conclusion, as Klaus R. Kunzmann says, *the IBA Emscher Park showed* (...) *that a region can be renewed through outputs images from the minds and exemplary projects that together follow an invisible strategy. It showed that, even at the time of globalization, an industrial region that for decades has* *neglected the countryside and living spaces can be a sustainable environment for people who want to live there* (14).

The urban voids appear as uninterrupted design of the city, (...) areas waiting for a morphological definition (24). Focusing exclusively on adding new functions to brownfields is a reductionist approach, according to Carlo Olmo, *because the city needs undefined spaces in order to be able to absorb the changes. Those who today are defined "grey areas" can be considered as spaces that allow to connect the times of the city with those of society* (25). It was exactly what happened in the Ruhr, an immense area redeveloped in order to face social and environmental needs. Although the economic support was significant and not always feasible in other reality, the concept behind this project is easily understandable and deserving to be used.

When the will is to reconvert the city of our days to a Post-Carbon City, it must be make through an awareness of weaknesses to those strengths. Some of the winners aspects that can be played are: composing a heterogeneous and experienced team seeking the active participation of citizens and taking advantage of the marks left by centuries of history. From the Ruhr, the main task was the inheritance of an entire region, and it can be definitively remained to the world which we will leave to the future generations. Now we have the possibility to don't let it implode. Since today, there are three generations of industrial reconversion. The last of these, draws its intent to sustainability, quality of life and environmental protection.

This is feasible through a targeted and short-term urban planning, the need for actionable strategies from the present and not the near future; since to the manifestation of an emergency you need to be timely. There are therefore, sufficient examples and testimonies, which make us, understand that evolution, the quantum leap is possible. With the depletion of oil, cases of reclamation and upgrading to a regional level will be essential. For the benefit of the planet, the man was the dominant role must return to nature.

Even if the public opinion is not cohesive as German citizens today are cultured and educated. The institutions have the opportunity to make use of international experts, in no time. Thanks to the internet can be provide education and awareness campaigns, in addiction have a direct access and the possibility of sharing instantaneously the knowledge required. In this way the specificity of the subject, can be easily understood. The technology allows a remote control, a continuous monitoring and recording of data, wherewith develop specific action plans, which can than be shown demonstrated as indispensable.

The case study mentioned above, is an awareness and a noble example of implementation and application of the tools that most of the nations have or can acquire.

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Policies & Regulations for a Sustainable Built Environment

A NATIONAL RESEARCH AGENDA FOR INTEGRATED SPATIAL PLANNING, LAND USE AND SOIL MANAGEMENT

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1_Introduction

The main purpose of INSPIRATION[1] project is to formulate, consult on and revise an end-user oriented Strategic Research Agenda (SRA) for integrated spatial planning and soil-water-sediment system management at the European level, in the light of the societal challenges addressed by the European Commission. Furthermore the project aims to identify some existing and new funding and delivery models for implementing the SRA and for bringing together public and private European research funders, who will to collaboratively and synergistically invest in delivering the SRA.

Beyond the European agenda, which will be developed and implemented within the next two years, research gaps in current activities on soils and land use related societal needs have been identified and prioritized at national level.

The project is based on a bottom-up and interdisciplinary approach, involving stakeholders and institutions within each country involved in the project. The vehicle to engage the stakeholders is the National Focal Point (NFP), a selected institution for each Country within the programme Consortium. Each NFP interviews National Key Stakeholders (NKS - such as funders, end-users and researchers involved in soil and land management), performs a desk study and organizes a local workshop with the participation of the NKS. The goal of these exercises is to gather information and support the specific objectives of the project, by organizing a cross-border and interdisciplinary dialogue among relevant user communities, funding bodies and scientific communities.

The paper illustrates the results of the first year of the project in Italy, within the Working Package n. 2 "Demands of research from industry, end-users and funders (State-of-the-art at national levels)". The Italian working group is based in the Higher Institute on Territorial Systems for Innovation (SiTI) of Turin and includes the authors of this paper.

Through key-stakeholder interviews, data analysis from indirect sources and the national workshop, the National Research Agenda for integrated spatial planning and soil-water-sediment system management has been set up. It synthetizes knowledge gaps and research needs in the fields of soil, water, sediment, urban planning, landscape etc., following the bottom-up and interdisciplinary approach advised by the programme.

The information gathered to define the National SRA has been collected according to the following methodology:

- The stakeholder analysis and selection of the key-actors among 29 organizations;
- 31 national Key-stakeholders direct interviews based on a structured questionnaire shared among the programme's members;
- A desk-exercise based on documents' review from indirect sources and from NKS suggestions;
- The identification of fund-raising models and scheme for research, as taken from indirect sources and NKS interviews;
- The organization of a 2-days national workshop reviewing and synthetizing the collected information (about 27 on 31 invited NKS took part to the workshop).

[1] INSPIRATION (INtegrated Spatial PlannIng, land use and soil management Research AcTION - www.inspiration-h2020.eu) an ongoing Coordination & Support Action developed under the EU Research and Innovation programme (2014 - 2020) "Horizon 2020" that involves 17 European Countries (Austria, Belgium, Czech, Finland, France, Germany, Italy, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK) and other possible additional partners (Sweden, Denmark and Luxembourg).

The next paragraphs give a synthesis of the main topics of the Italian Research Agenda for integrated spatial planning, land use and soil management. The agenda aims also to give suggestions to improve these researches, by critically analysing the science-policy-practice interface and the funding schemes, and suggestion to find opportunities available locally.
The second paragraph illustrates the Research and Innovation (R&I) needs emerged from the interviews and shared during the national workshop. The third reflects on the NKS' experiences regarding the connection between science and policy/practice and the actual NKS' possibilities to set the agenda. The fourth describes the national framework of national and transnational funding schemes and opportunities, highlighting the most suitable for the research on spatial planning and soil-water-sediment system.
Finally, the conclusions focus on the role of the research planning in Italy, the process followed in the project and the most relevant research themes highlighted in the Italian agenda.

2_Research and innovation needs on soil, land use and management

2.1_Societal challenges and needs

All National Key stakeholders were asked to express their opinions on the societal challenges[2] identified by the European Commission. The majority of the NKSs consider as important all the societal challenges already proposed and some of them recommended reorganizing and grouping them into main families that can include minor topics. So, some specifications and additions have been introduced. According to some NKS the challenges from EC "ensure secure supply of safe drinking water" and "ensure efficient use of natural resources" miss the idea of safeguard and its relation with ecosystems, which means something more than just ensuring the supply. The challenge to prevent the hydrogeological risk and the water maintenance should be noticeably considered as well. Risk management particularly is often named, but it is generally considered as implicit within the EC challenges, namely in the one called "ensure secure infrastructure".
The reduction of land take is another societal challenge regarded as important, which some NKS consider implicitly included in the EC challenges (but in that case they think it should be highlighted), but others say that it should be specifically added to the list as an individual challenge.
Furthermore, during the national workshop, the "Zero land take balance" has been shared as a new societal challenge that should be added in the list; and related to this last, then NKS suggested also the one "Promote the economy of recycle and reuse.
Some NKSs argue that social inclusion and sociological aspects in general should be included as well. For someone it means to involve people in decision making processes on environment and land use, while for others it means to improve the culture of environmental sustainability through public engagement, organizing citizen's trainings to increase awareness on the topic, or even to overcome the technical aspects of land use, taking into account the societal impacts. Following this topic the new challenge of "Ensure social inclusion" has been added to the EC list.

[2] The EC societal challenges are: Contribute to food security and food safety; Ensure secure supplies of safe drinking water; Secure energy supply and distribution; Reduce Raw material and resource consumption; Ensure efficient use of natural resources; Contribute to climate change mitigation and societal adaptation; Contribute to a healthy and safe living environment; Ensure secure infrastructure. (only the word safe in italic has been added within the EC suggested challenges).

The last societal challenge recommended by the NKS during the national workshop is "Improve ecosystems resilience", which could be considered a wider cross-sector challenge.

2.2_Topics and research needs to include in the Strategic Research Agenda

General topics and specific research questions about soil, land use and land management (including the soil-water-sediment system) were previously listed by the NKS during the direct and individual interviews; then they were shared during the 2 days national workshop. The result is the following list. The specific research questions are described in short paragraphs and are grouped in main general themes (corresponding to level 3 headings).

2.2.1_Sustainable management of natural resources:

a. *Optimization of water use in agriculture*. Agriculture is the main water consumer and the productive cycle of crops requires large water volumes. The water resource is available in limited quantities; therefore optimizing the use of water in irrigation is needed in terms of sustainability. A contribution to this research topic, even financial, could come from irrigation consortia, which are economically strong bodies who govern water management in agriculture.

b. *Water purification technologies for reuse*. For example, phytoremediation not always achieves optimal results; therefore would be important to analyse existing technologies and to implement them, even creating innovative tools. The use of these technologies can ensure safe water for agriculture, contributing to food security and safety.

c. *Recovery and treatment of rainwater*. The water cycle (primary water, rainwater and treated wastewater) should be integrated by implementing existing technologies and developing appropriate strategies of intervention and management. The legislation already works in this direction, but it's important to promote a sustainable water management based on the local needs and conditions. Particularly these strategies are required in some Italian geographical areas, which are characterized by limited presence of water. A diffused culture of sustainable consumption and of water reuse should be also promoted among citizens.

d. *Genetic selection practices and techniques (GMO)*. The challenge of Genetically Modified Organisms is to mitigate farming impacts and to increase crop production; GMO are able to make plants more resistant, so reducing the use of chemicals. In Italy GMO field trials are forbidden, but genetics is a research priority. According to some NKSs, research on GMO can help to answer an increasing food request with a limited soil availability, assuring same production with less chemical provision. But others strongly disagree. The lack of scientific certainties about the long-time effects on consumers makes the theme strongly debated and requires to be studied in depth.

e. *Development of conservative agricultural techniques*. Conservative agricultural techniques are able to guarantee greater stability of soils, thus mitigating impacts on soil biodiversity and saving soil fertility; while massive "industrial" techniques for food production don't take in account soil and biodiversity as a limited resource.

f. *Land subsidence monitoring and management*. Net impact on global and regional scale. To measure the effects of subsidence, various components have to be considered: natural, tectonics, geological, anthropic etc. Risk areas should be adequately monitored by measuring precisely the vertical soil movements. The current measuring methods aren't still able to take to fully describe this complex phenomenon.

g. *Integrated operating models for soil and sediment management and reuse*. Ground movements caused by human or natural reason, in urban or suburban areas, river or lake areas, generate ground and sediments that could be reused in situ. It's important to create models, technologies and tools for their reuse.

2.2.2_Contamination of water, soil and sediments:

a. Improvement and harmonization of risk assessment and management tools. The health and environmental risk analysis of contaminated sites is required by many Italian lows, but we still need validated and integrated tools in order to apply actually the methodological criteria scheduled by the law. NKS have different opinion about the actual needs of research on this topic, but for some of them it is very relevant.

b. Study of emerging contaminants (bio-accumulation and bio-dispersion), and study of mixtures and of matrices contamination. There is also a lack of attention in the law about the emerging pollutants and their consequences on the environment and people's health.

c. Sustainable remediation technologies and procedures. Many NKSs raise questions about the remediation procedure: very high cost, waste of time related to bureaucracy and decision makers disagreements, lack of best practices for the impact assessment, weak interaction with research, lack of clarity and uncertainty of the legal system, lack of knowledge about specific soils (notably Italian lands are very diversified). It's one of the most cited topic and it's priority is considered very high by all the NKS.

d. Models and tools for the definition of Europe-wide harmonized indicators for contaminated sites management; the data management of contaminated sites data management from the local to national level has to be optimized as well. The information flow about contaminated sites has to be harmonized in order to optimize the data management, starting from creating a national database of contaminated sites (currently only few regions have it).

2.2.3_Spatial and urban planning:

a. Land management models and instruments oriented to zero land take balance. Despite the peculiar fragility of its lands, Italy is one of the highest land taker in Europe. The mitigation of land take, together with land safety, urban renewal and regeneration, as well as the reuse of contaminated areas, should represent a strategic objective in Italy (Ispra, 2015). This is definitely the most cited topic, asking for new effective strategies (new policies, new laws, and new procedures).

b. Urban regeneration models and tools to strengthen urban resilience. Promote strategies and urban policies focused on the reuse of abandoned areas and buildings (including brownfields and their remediation), looking to 'zero land take' horizon. Afterwards the massive industries' disposal, indeed, wide soils (which during the industrial age were outside the city, but currently are within) need to be remediated. The strategic position of these lands is very relevant, both in term of real estate and urban densification, thus reducing new land take.

c. Soil ecosystem services protection and management. Ecosystem goods and services are the direct and indirect contributions of ecosystems to human wellbeing. Ecosystems provide four different categories of services: provisioning services, regulating services, habitat or supporting services and cultural services. Ecosystem services indicators (to define and measure by the research) could be integrated into existing planning tools (notably in the Strategic Environmental Assessment - SEA) and into soil administration models (to design by the research as well). These processes contribute to soil sealing reduction and to shrink the loss of fertile soil and biodiversity, thus contributing to zero land take balance.

d. Study of the relationship between built environment and health. Nowadays it is recognised that built environment have an impact on human health and wellbeing and that actions aimed at improving health are likely to be influenced by the environmental and socioeconomic context in which they take place. Therefore urban design and planning can play an important role in this context. Several studies on this issue have been developed during the last years but research based on empirical data is still missing.

e. Landscape quality indicators in spatial and urban planning. The need for indicators to evaluate and monitor the effects of landscape policies and plans is a big research topic related to land management and environmental issues. Landscape is already considered in spatial and urban planning and in SEA, but unlike air, soil, or water, It's difficult to measure it using quantitative methods, because of its multiple dimensions. Both practitioners and public authorities can profit of this research, which can offer a contribute to landscape policies, plans and landscape assessment (within Strategic Environmental Assessment and environmental impact assessment procedures and multi-criteria assessment methods)

f. Monitoring Information Systems and flood risk management techniques. Water monitoring systems could be a worthwhile investment in research by accessing and organizing local data at the national level. With a global perspective (of the whole country and ideally worldwide) we could save resources by identifying real flood risks and acting to prevent it.

g. Erosion and runoff models and scenarios. The risk of surface water runoff represents a soil threat. The main soil degradation processes involved are: soil erosion and soil contamination by transferring Plant Protection Products (agrochemicals), soil fertility and soil biodiversity loss. The erosion phenomena is very big especially on the hills, with relevant economic impact on valuable crops.

2.2.4_Crossing themes:

a. Supporting tools and methods for decision making. How to optimize decision making among stakeholders? This is a high matter among NKS. Working groups shared with researchers, public institutions and with all the stakeholders are coveted. Technical decision analysis, decision making supporting systems and tools can be able to provide support throughout the decision process.

b. Risk Information and communication. Effective communication of information and opinion on risks associated with real or perceived environmental hazards is an essential and integral component of risk management. Providing meaningful, relevant and accurate information, in clear and understandable terms targeted to specific audience, can led to more widely understood and accepted risk management decisions. Research and development of ICT tools and metrics, as well as guidelines on mitigation strategies and implementation methodologies, can contribute to effective risk communication.

c. Rationalization and efficiency improvement of the political-administrative system (agencies). To exemplify: water management agencies in some Italian regions are supernumerary, like Sicily that has 7.000 agencies that deal with water comparing to the 22.000 in total in the country. The administrative system has to be reviewed, because this lack of efficiency has heavy economical consequence on the national and regional financial budget.

d. A new theory of value to associate with environmental issues. This research need is focused on the aim of making nature's economic values visible and mainstreaming this values into decision-making at all levels. A new theory of value (in economic terms) is needed in order to achieve this goal. A structured approach to valuation can helps decision-makers to recognize the wide range of benefits provided by ecosystems and biodiversity.

3_Science – policy – practice – society: a weak chain

3.1_Science – policy – practice – society

The science-policy-practice interface is a complex issue in Italy. Research programmes can influence it, but it can depend on the real impact of researches and on the research demand as well, and moreover on the process of orientating research supply and demand. The National Research Agenda for integrated spatial planning and soil-water-sediment system and notably the European Strategic Research Agenda (SRA) for land use, land use changes and soil management, promoted by INSPIRATION, aims to build a virtuous encounter between research supply and demand on soils topics by following a bottom-up and interdisciplinary approach. Research is typically more effective when orientated by end-users, such as decision makers, industries and businesses; thus, listen to them is the first best way to improve the science-policy-practice interface.

Research outcomes in the NKS experience have been effectively transferred into policy making or business opportunities quite rarely. Definitely many NKS complained the lack of research impacts into practices or policies,

which generally means a lack of applied research and a weak link between scientific research and practices or polices. It doesn't mean that the question is only a general incapacity of knowledge transfer (a matter that however was often cited), but is also the political conflict that sometimes emerges because of the research outcomes (e.g. if research results imply an unpopular choice, these will be likely rejected by decision-makers).
Therefore the science-policy-practice interface in Italy appears more like an inverted process, such as a policy-science interface. It's a quite hierarchical process: from the institutions to the scientific world. The research world sometimes has been accused from NKS to be auto-referential and not so able to communicate with the outside world, with the risk to waste research efforts for unused results. Other times the focus was more a political matter (as mentioned above).
Furthermore research impact is related to society in general, enhancing the science-policy interface to society. But in Italy the societal impact of research isn't actually assessed, at least not systematically. University and public research centres that benefit from public funds are scientifically evaluated[3] considering research products of researchers and professors assembled in each faculty/department and not individually. Nonetheless the National Agency for the Evaluation of Universities and Research Institutes (ANVUR), within the Quality Research Assessment, evaluates the public engagement of single department and universities, without considering the impacts of single researches, but simply considering how much time professors are involved in public engagement activities and which kind of public engagement activities are promoted (until five activities for each university, until two for each department). Only research centres and institutions (including universities) use to make a Social Responsibility and Balance Sheet or Social Audit, but it refers generally to the research infrastructures and not to single researches or research groups.

[3] The research in Italy is evaluated for quality performances according to peer review processes and bibliometric parameters by the ANVUR within the Quality Research Assessment (the Italian acronym is VQR).

3.2_Possibilities to set the agenda

The NKS have a weak possibility to influence policies agendas. Policies agendas aren't necessarily related to scientific research, but those can involve some research activities. NKS that are within public authorities, such as institutional bodies, or which are strictly linked with them, such as governmental agencies, act under a clear political orientation (as explicitly written in the agency constitutive statute). It means that, if they are involved in a specific research, it's because of the political interest in that research and rarely they can suggest different research topics autonomously. Nonetheless it could happen that research outcomes are not used profitably by politicians; especially because of their temporary condition, which could last less than the time needed to develop the research.
Others NKS don't feel themselves or their institution truly able to influence policies or practices in general, except who is part of the major research centres, which can provide important support to the government (notably the ministries) in identifying methods and action strategies; even if there isn't any institutionalized or standard procedure of consulting.

Considering that almost any NKS has ever been involved in the formulation of national research agendas, don't surprise that the National Research Programme (PNR) is rather unknown to most NKS. People from science sector at least know some specific programmes included in the PNR. Anyway any NKS has ever been consulted for the PNR design.

The PNR is a three-year programme prepared by the Ministry of Education, Universities and Research. The last PNR (2014-2020) has not been definitely approved yet, but a draft is available. It doesn't refer to specific topics (like environmental issues or land management), but it's focused on different typologies of programmes, such as research infrastructures, scientific excellence and industrial leadership (in the wave of the European Horizon 2020 R&I programme).

4_Research funding: opportunities and gaps

4.1_Funding schemes and possibilities for research funding

In Italy there is a generally short supply of research founding. The general spending percentage of R&D on the national GDP in Italy is only 1,26% (in 2012), much less of others main countries, such as France (2,23%), Germany (2,88%), UK (1,63%), United States (2,70%), Japan (3,34%), China (1,98%), Israel (4,25%) . Despite of a little growth in the R&D spending in Italy from 2009, the ISTAT announced for the next years an expected decrease in R&D expenditure of public institutions, but an increase of 1.4% of private companies.

Facing this discouraging scenario, anyway some national funding for research are available but the major opportunities came from Europe. Here are distinguished several main categories: public and private, at the national level or at the local level, and other transnational funds. Except the last group, all the following funds are national and totally from the State or private.

4.1.1_National public funds

The main Italian funding schemes for research founding are provided within the National Research Programme (PNR), prepared by the Ministry of Education, Universities and Research. The last PNR, not definitely approved yet[4], provides three main funding schemes for research and research infrastructures: "Scientific Excellence" (blue), "Research Infrastructures" (red), "Industrial leadership" (orange). Within each group are provided some enables, which correspond to specific programmes and amount of funding. Beside the National Research Programme, other national public funds for research are provided by the same Ministry of Education, Universities and Research (MIUR) and others Ministries (like Ministry of Economic Development, Ministry of Agriculture, Food and Forestry, Ministry of Environment, Land and Sea, Ministry of Infrastructure and Transports) directly to national research centres in order to finance the structural functioning of the institution (if the Ministry is the MIUR) or to finance specific research projects (for the others). The public research centres involved in the INSPIRATION's topics are the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) and the National Research Council (CNR) with its institutes.

[4] At the time of the SBE 2016 Conference, 18-19 February 2016.

Funding opportunities for future research on land-use and -management and related impacts to Soil-/Sediment-/Water-systems are also available nationally within the PNR programmes and within the next calls that will be open by the Operational Programmes 2014-2020 available nationally or locally (in the regions).

Other funding schemes public to public are provided nationally by public authorities (within the INSPIRATION's themes e.g. are Port Authorities, but could be even the Regions or others) to national public research centres (like ENEA or CNR above mentioned) or to public universities or, if specific competences are needed, to private research centres.

4.1.2_Regional or local public funds

Funds for research are also invested from the Regions or other local public authorities (such as Cities or Metropolitan Cities etc.) in order to finance the structural functioning of regional research institution (in that case are the Regions that fund their own research agencies, such as IRES or IPLA in Piedmont, or EUPOLIS in Lombardy etc.) or in order to assign specific research projects (usually is applied research) in their "personal" interest to universities or others research centres (even private if needed).

4.1.3_National and local private funds focused on environmental issues

Research funds in Italy are provided also by banking foundations, mostly located in northern Italy, or research foundations, often participated by public authorities. They operate locally, investing their funds in specific areas identified in their own Charter. They can provide funds to groups (partnerships with associations, companies, NGO etc.) or to single researchers, covering the whole research cost or just a percentage depending on the specific call and its objectives.

Professional associations, such as federations or corporations of specific sectors (like industry, agriculture, commerce, architecture or engineering) could provide research funds as well. They usually don't have a specific research program within the organization, but they could co-fund other research projects externally or sometimes they publish specific calls that involve professionals in an applied research project or in projects that can include research activities. In any case the research funds they provide are just a little part of their financial capital, because research, when taken into account, is a secondary aim for them.

Some companies also invest some funds in research and development, mainly in the Northern Italy (75,7% in 2012, compared to 15,6% in the Centre and 8,6% in the South). The spending percentage of R&D invested by companies on the national GDP in Italy in 2012 was of 0,69%, compared to France 1,44%, Germany 1,91%, UK 1,05%, Spain 0,66%; facing the European average of 1,20%. Research then can be developed *intra-moenia* or *extra-moenia*.

4.1.4_Other funds

The most part of the NKSs experienced researches totally funded by Europe or co-funded by various European countries; instead very few benefited of national financial resources. So, within the possibilities for research funding, we should necessary consider other typology of funds (even if not purely related to research) than the only national one. Particularly we consider funds related to the European Territorial Cooperation and the European Structural & Investment Funds as well.

Research funding schemes managed directly by Europe, such as the Framework Programme for Research and Innovation Horizon 2020 or the LIFE financial instrument that support environmental, nature conservation and climate action projects throughout Europe, are excluded from the national agenda because they will be largely deepen in the next phase of the programme, shared at the European level.

The main funds experienced by NKS are calls opened within the European Territorial Cooperation (ETC), better known as Interreg: cross-border (Interreg A), transnational (Interreg B – notably Med was cited) and interregional (Interreg C). These programmes aim to promote joint actions and policy exchanges between national, regional and local actors from different Member States, which can include research activities, even if research is not the main scope of these programmes.

Other research and opportunities were cited by NKS within the European cohesion policy funds; despite they aren't again research-driven funds. These were calls opened within specific Operational Programmes available nationally or locally (regional), which benefit of the European Regional Development Fund (ERDF) and the European Social Fund (ESF). Considering the INSPIRATION's themes, the European Agricultural Fund for Rural Development (EAFRD) are also appropriate. Using these funds, calls are opened within the national and/or regional rural development programmes (RDPs). Some NKSs cited the RDPs as "research" fund opportunities as well.

4.2_Financial resources for research: a SWOT analysis

Starting from the main gaps in financial resources for research in Italy, during the National Workshop we develop a SWOT analysis in order to make critical considerations and to suggest some strategies for implementing the current available funding schemes.

The main gaps originally identified were:

- The lack of efficacy of research project and the lack of control on final research results: research outcomes often ignore their application in the real world and disregard the market needs;
- Dissemination and communication of funded projects are often considered too poor and ineffective;
- NKS opinions about private funding for research are divergent: some are definitely in favour; others fear that the interests for profit would outweigh the public interest in research.

These issues have been discussed during the workshop, while working on a SWOT analysis. Strengths were quite few compared to weaknesses, but opportunities compensate threats. Many issues had strong relation with the chain of science – policy – practice – society, highlighting that financial resource optimization works along with a stronger connection among scientific research, policies/practices and society.

Strengths	Weaknesses
Spread of several research centres (but at the same time the lack of "strong" research infrastructures) Presence of many experienced researchers in Italy (infrastructural and human capital) Effective laws for tax exemption and patronage for research investments	Scarcity of ordinary resources available for research (especially for basic research); Segmentation of skills and the lack of integrated funds; Weakness, or even the absence, of planning of environmental and land policies (and practices); Weakness of the science-policy interface; Low skills on funding schemes and on intercepting financial resources (e.g. Consider that the ability to intercept European funds – including the SIE – in Italy is statistically very low: the success rate of the Italian answer to calls in 2015 is less than 9%); Lack of transparency of selection procedures within national research calls; Decision uncertainty of policy-makers and poor judgment about land management sustainability.
Opportunities	**Threats**
The strategic role that the private social (community foundations) can play in research, offering funds and posing research question; Implementation (and importation) of co-funding and co-design research experiences spread word-wide; Implementation of bottom-up processes oriented to define research agendas; Promotion of a long horizon in research planning; Intercepting of the "grey zone" of research demand; Optimization of the incentives system about energy; Consultation among actors and the creation of a virtuous supply chains; Introduction of mixed brokerage subjects, including funders, knowledge producers and end users; Spread of tax credits.	Fragmentation of researches and the of overlapping among research topics; Risk of investment dissipation related to managing waste and lack of efficacy of research project (as already asserted by the NKs during the interviews); New role of Universities as "professional advisers": to be understood as new practice developed in order to compensate the lack of financial resources into the Italian university; Conflicts of interest between the research word and the large-scale industry, following the cited gap of NKS divergent opinions about private funding for research. Diffused weak of knowledge of client in the private market, often not aware of the benefits offered by research.

Calling back the main gaps initially highlighted by NKS, the matter of project dissemination and communication seems disappeared, but more specifically appeared the issue of risk information and communication among the renewed list of research topic discussed during the workshop.

5_Conclusions

INSPIRATION Project highlights the importance of adopting a research agenda, as a planning strategy oriented to define and share common research themes among stakeholders and to improve the investment effectiveness of research funding. This is very important, especially for Italy, where there isn't a long lasting tradition in setting research agendas. Indeed, almost any NKS has ever been involved in the formulation of national research agendas before, even if most of them participated in specific research projects and proposals. Nevertheless the idea to set national and transnational research or policies agendas is beginning to spread in the Country already before INSPIRATION. Actually Italy (Italian research organizations and funding agencies, administrations and industries) is participating in some European research agendas related to land use and to the soil-water-sediment system[5].

Furthermore, we would like to stress the process used to set the agenda, which is based on a bottom-up and interdisciplinary approach, involving the national key-stakeholders (funders, end-users and researchers) through direct interviews and a national workshop. Research topics have been identified following a participatory approach: listening to relevant user communities, funding bodies and scientific communities.

Finally, among the four themes suggested by the NKS, is important to underline that a particular interest was dedicated to the crossing themes. Supporting tools and methods for decision making, risk Information and communication, rationalization and efficiency improvement of the political-administrative system (agencies) and a new theory of value to associate with environmental issues, are the most suggested ones. This fact shows once again the matter to enforce an holistic and interdisciplinary approach in environmental research: soil, water and sediments have to be consider together, both from the spatial dimension and from the competencies, rather than separately, from different sectors or disciplines,

Consequently a cultural change in approaching the environment seems to be needed. NKS said that we basically know how to solve environmental problems technically, but the biggest issue is how to connect them: which are the environmental charges and benefits of land management? Which are the environmental economic and social costs behind decisions in planning for the environment? How to involve all the stakeholders in decision making? Looking at the Horizon 2020, an ecological and multidisciplinary vision of urban and rural environment is needed to face the societal challenges suggested by EC. If research moves in separate fields we won't manage to face adequately both the social and climate changes.

[5] For example: the Strategic Research Agenda launched by the Joint Programming Initiatives on Agriculture, Food Security and Climate Change (JPI FACCE) in 2012, (updated by the "First Biennial Implementation Plan 2014-2015"); the Strategic Research and Innovation Agenda within the JPI Water challenges for a changing world (2014); the Strategic Research Agenda adopted by the JPI Connecting Climate Change Knowledge for Europe (2011); the Strategic Research and Innovation Agenda launched by the JPI Urban Europe in 2015: Global Urban Challenges, Joint European Solutions.

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Abstract

Strategies for sustainable urban development are an important element in achieving sustainability on the ground. They provide integrated long term plans that are necessary for sustainable development. However, after years of experience with urban sustainability strategies, the results are rather mixed. While in some cases sustainability strategies have proven to be useful tools, in other cases they could not sustain local change.

In this context, the city of Berlin, a city with a tradition of Local Agenda 21 and a lively past of local sustainability activities, decided to develop the Berlin Sustainability Profile. This is a cutting edge innovation in the field of local sustainability strategies. This paper gives answers to the questions, what is a local sustainability profile and how can sustainability profiles contribute to sustainable urban development. The answers will be provided with the help of the case study Berlin.

LOCAL SUSTAINABILITY PROFILES A NEW APPROACH TO URBAN SUSTAINABILITY STRATEGIES

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1_Introduction

Local sustainability strategies can significantly contribute to the sustainable development of a city and have therefore seen wide application for many years now. However, developing and implementing local sustainability strategies is a complex intense endeavour. Hence it is not surprising that, next to success stories, there is also a significant number of cities that did not meet the expectations they had for themselves when first starting to work with the tool of local sustainability strategy. Against this backdrop of mixed results with local sustainability strategies, a new approach was developed by the department for urban development of the city of Berlin. This approach is called the Berlin Sustainability Profile ("Berliner Nachhaltigkeitsprofil"). This paper will deal with the underlying idea of a Local Sustainability Profile (LSP) and its first prototype, the Berlin Sustainability Profile (BSP).

First, this paper will describe the status quo of local sustainability strategies and the challenges faced by many cities when trying to make use of this tool. Second, the underlying idea behind a Local Sustainability Profile will be introduced and a few characteristics for a design thereof will be suggested. Additionally, the Berlin Sustainability Profile will be introduced as the first application of this new approach. Before concluding, this paper will offer some reflections on the idea of a LSP in general, the case study BSP and its design process.

This paper will provide answers to the questions what is a local sustainability profile and how can sustainability profiles contribute to sustainable urban development? It claims that sustainability profiles are a noteworthy new approach to local sustainability strategies and could contribute to local sustainability governance also in other cities.

2_Local Sustainability Strategies – state of the art

Local sustainability established itself on the global policy agenda with the 1992 Rio declaration (chapter 28). It was the starting point of the Local Agenda 21 (LA21), which approximately reached its peak internationally in the early 2000s (Rok, Kuhn, 2012). Around the peak of LA21, local sustainability strategies emerged on the scene. This new approach combined urban development strategies with ideas of local sustainability and LA21. As reference points for this turn we can take two international conferences. First, the Johannesburg summit in 2002 where, for example, the German state of Bavaria presented insights from a prototype local sustainability strategy, the "Visionen für Ingolstadt" ("visions for Ingolstadt"). Second, the Aalborg Commitments, adopted in 2004, which call for many aspects that were then taken up by municipalities in the form of local sustainability strategies. From around this time on, sustainability strategies gained increasing recognition and application at the local level.

Towards the end of the 2000s, local sustainability strategies became more refined, due to increasing experience with this tool. Thus, local sustainability strategies were often embedded in a wider context of local sustainability management. An example thereof is the Integrated Management System (IMS) as developed and tested for a European context in the framework of the project **"Managing Urban Europe 25"** (MUE25) (localmanagement.eu, 2005) between 2005 and 2009 and later followed up by projects such as **"CHAMP – Integrated Management for Local Climate Change response"** (2009-2011) (localmanagement.eu, 2009).

A local sustainability strategy in this context often follows a basic sequence of steps, which contains a baseline review and description of the status quo, a vision for the city with concrete aims, a set of indicators to monitor the achievement of these aims and finally an action program. A management process, such as the IMS mentioned above, would integrate this structure into a cyclical process and add the steps political commitment (e.g. council decision), implementation/ monitoring and evaluation/ reporting. Throughout this cycle, cross cutting elements such as a coordinating unit (organizational setup) and participation of citizens or stakeholders (involvement and communication), should support the process.

This kind of sustainability strategy and management system has led to mixed results over time. While some cities have made generally positive experiences with this approach and have advanced over the years, others experienced difficulties. The 25 cities that participated in the Managing Urban Europe 25 project can serve as an example. Some of the participating cities in the MUE25 project continued and deepened their integrated sustainability efforts to the point that sustainability is a defining element in these cities' self-understanding. Examples are Ludwigsburg in Germany, which won the German sustainability award in 2014 (Ludwigsburg.de, 2014), or Växjö in Sweden, which promotes itself as "Europe's greenest city" (Vaxyo.se, 2015). Other cities are still active in the field of sustainability, but have changed their approach to more topic and project based work. Lastly, a number of cities from the MUE25 project do not seem to show any more noticeable efforts in the field of sustainability today. This three-tiered development seems to be exemplary for other cities in Europe as well.

Barrutia et al (2015) indicate a number of reasons for the mixed results and experiences of local sustainability strategies. Among them are, the challenge to plan for the long term, the difficulty in measuring success through indicators and keeping a balance between long term vision and short term success stories. Furthermore, the element of participation, which is deemed a necessary element for creating a sustainability strategy has proven rather demanding for some cities. Underlying these challenges is the fact that creating and implementing a local sustainability strategy as described above can be quite resource demanding.

Sustainability reform requires time. To achieve sustainability many intricate and complex factors need to be tackled. Therefore, a local sustainability strategy also needs to plan for the long run. However, successful long term planning depends to a large degree on cooperation across different sectors and between bottom-up and top-down actors, which is a rather ambitious requirement (Eckerberg and Dahlgren, 2007, Nolting and Göll 2012). A factor keeping actors involved might be to share common success stories. Yet, this would require a delicate balance between long term goals and short term achievable objectives within a local sustainability strategy. Furthermore, long term planning might be less successful in a case with limited finances (Patterson and Theobald, 1996).

Identifying a set of indicators in order to measure the success of a local sustainability process over time is often seen as another crucial element of a local sustainability strategy. First, it can lead to creating the above mentioned success stories and second, policies need to be evaluated in order to determine if alterations are needed. In the case of local sustainability strategies and LA21 processes, it is often assumed that indicators should be determined through participatory processes and defined for a specific local context (Barrutia et al, 2015). However, determining indicators is a challenging task since they should be, among other things, meaningful, valid, comprehensible, feasible and data collection should not exceed a justifiable effort. Despite all efforts, to find such indicators in cities the results are not always conclusive. The LA21 process in Berlin, for example, selected “research spending” as an indicator for innovation in the city. Although useful, it is questionable if this indicator can provide significant evidence of something as complex as innovation. Next to such technical difficulties, Ortega Cerdà (2005) claims that the selection of indicators is linked to their “capacity to be useful for the wielding of power and not with their capacity to be “objective” or “true”.” (p.11).

Participation is certainly an element that received a strong push with the LA21 movement. It is also often considered an essential part of a local sustainability strategy. However, participation does come with a number of challenges. They can be grouped into quality of participation and impact of participation. The quality of participation depends to a certain degree on the mix of participants. Yet, different research suggests that it is difficult to attract and include certain groups to a participation process. Such groups include for example the business community (lack of interest) (Worthington et al., 2003), women (discrimination) (Buckingham-Hatfield, 1999) and children (lack of understanding) (Chawla, 2001). Also it has been suggested that municipalities specifically target participants that have positive attitudes regarding sustainability ideas (Sharp, 2002), which leads to biased groups. The other scenario however, including a broad group of participants, can make it difficult to find consensus at all (Steiner Brandt, Tinggaard Svendsen, 2013)

. Yet even if participation takes place with a balanced group of participants, the impact such a process has is often questioned. Novy and Hammer (2007) for example claim that participation does not necessarily have the capacity to divert municipalities from existing unsustainable regimes. Harvold (2003) points to the difficulty in aligning existing planning policies with the results of participation. And Adolfsson-Jörby (2002) suggests that municipalities might not be willing to let participation influence substantial decisions, thus only allowing cosmetic or symbolic processes.

Local sustainability strategies can at times be rather demanding of resources. First, in their creation process and later in their implementation process. Creating a local sustainability strategy requires time, money and/ or staff capacity. Participation for example is a time and resource consuming exercise and Patterson and Theobald (1995) suggest that lack of resources keeps municipalities from engaging in activities of deliberated local change. Also working time in a municipality can be an obstacle to organizing a local sustainability strategy process because a coordinating unit needs to be carved out of often limited staff capacity. This can reduce first, the willingness to even enter into such a process by the municipalities and second, the willingness of the responsible staff to take on this additional task. Furthermore, the implementation of a local sustainability strategy requires resources and might be impeded by municipal budget constraints. As one reason, the challenge of long term planning, as explained above, can be mentioned, as well as the simple fact that individuals and organisations have to change their way of thinking and their everyday behaviour and routines.

3_Local Sustainability Profiles – a new approach

Although, "local sustainability profile" is a new concept, the term "sustainability profile" has been in use for some time before. Most often it has been used so far for private enterprises or universities (e.g. **Enel**, **Maersk**, or **University of Houston**). In some cases the term was even used in the context of local sustainability to describe sustainability on a district level (Jensen, 2009). However, in these cases sustainability profiles tend to be baseline reports or indicator based monitoring systems of an organisation or an area. Useful and important as such descriptions are, this is not the approach of the Local Sustainability Profile as described and proposed in this paper.

In any case, a profile is a view across an object, which allows for the identification of strong and weak parts, clusters, extensions, stampings and characteristics. Yet, while the guiding question for a sustainability report might be "In how far does an entity reach a certain definition of sustainability?", the guiding question of a local sustainability profile is "what are the strengths and talents of an entity to achieve sustainability?". It is therefore not a static description of a point in time, but an identification of dynamic fields of activity, so called "profile areas".

Thus, a local sustainability profile does not define sustainability aims for a city. The profile areas show different paths and activities, through which a city is approaching sustainability already today and how it could better achieve sustainability in the future. The profile areas are therefore descriptive as well as visionary. Their aim is to communicate what a city should focus it's efforts on in order to become more sustainable with a limited amount of, or no additional resources. By doing so, the profile areas show concrete opportunities for action, but also opportunities for communication and collaboration between different actors. The concrete use and application of a local sustainability profile however, needs to be defined in each case individually. A local sustainability profile is hence not a complete sustainability management system, but rather a building block in the architecture of a city's sustainability efforts. The core of a local sustainability profile are the profile areas. They describe the paths through which a city is achieving sustainability. In order to fulfil that role they have to meet a number of criteria. First, they have to each integrate all dimensions of a city's definition of sustainability. Each profile area is a different path in order to reach this definition. Therefore, second, the profile areas have to be across traditional policy fields and integrate those. Third, the profile areas have to be balanced in their level of abstraction: concrete enough in order to be operationalized while abstract enough in order not to get confused with established policy fields. Fourth, the profile areas have to be balanced in their integration of description and vision. On the one hand, identify strengths of the city today while on the other be ambitious and prepared with regard to future challenges of a city. Lastly, the profile areas should be uniform in their character e.g. are they effect oriented, an instrument that needs directed application, or maybe a passive construction principle.

4_Case Study – The Berlin Sustainability Profile

4.1_Background local sustainability action in Berlin

The city of Berlin has a lively and active history of local sustainability efforts. Individual groups, inspired by the call for local action of the 1992 Rio conference, became active in the city as early as 1993 (Stadtentwicklung.berlin.de, 2015). By the end of the decade local authorities, first district administration and later followed by the Senate administration, started engaging with and supporting local agenda 21 activities. A major player since 1995 was the "Roundtable for Sustainable Development Berlin and Brandenburg". Between 1998 and 2001 two inquiry commissions (Enquetekommission) were set up by the city parliament (Abgeordnetenhaus). The commissions each published indicative assessments and recommendations for sustainable development in Berlin. Since 2004, a registered non-profit association, Berlin 21 e.V., coordinates the activities of civil society groups linked to the local agenda 21 idea. In June 2006, the Abgeordnetenhaus passed the "Lokale Agenda 21 Berlin" as a vision for local sustainable development. This resolution follows the common structure of sustainability strategies of its time: a problem definition is contrasted by a vision for the city and fields of action are enriched with aims, indicators and concrete action plans. The "Lokale Agenda 21 Berlin" resolution was taken as the basis for the "Core Indicator Report for Sustainable Development" which is published biannually since 2012 and monitors sustainable development in the city in 16 core areas. As a continuation of these efforts, the Senate Department of Urban Development and Environment, started in late 2014 to develop the Berlin Sustainability Profile (BSP).

4.2_The Berlin Sustainability Profile – structure and content

The creation of the Berlin Sustainability Profile followed the publication of the "BerlinStrategie", the city's urban development plan until 2030 (Senatsverwaltung für Stadtentwicklung und Umwelt, 2015). The BSP focuses and elaborates the sustainability dimension of this urban development plan and identifies Berlin-authentic approaches to sustainability. The BSP has a primarily communicative character. Its aim is to show the many activities in Berlin and to motivate actors in the city to prioritize and focus their efforts within the profile areas that the BSP identifies. Furthermore it invites actors to collaborate across their traditional areas of action and within the profile areas identified by the BSP. These profile areas are labelled the Enabling Berlin (Ermöglichendes Berlin), Productive Berlin (Produktives Berlin) and Accessible Berlin (Zugängliches Berlin).

The Enabling Berlin reflects on the city's strength and potentials to offer space for creativity, experiments and self-realization of individuals, companies and other institutions. This space to try out new things is both material and cultural. It refers to the still high amount of clearances and public space, relatively affordable space for housing and offices as well as to a generally perceived tolerance for novelties and innovation in Berlin. The Enabling Berlin contributes to sustainable urban development by allowing and supporting sustainability innovations. These innovations can be products, services or sustainable lifestyles.

The Productive Berlin considers the local production, reuse and recycling of resources that are consumed in the city. It refers to resources as natural, economic, social and cultural resources. Complementary to the connections with the wider world, Berlin provides for its needs within the city limits and within its immediate surroundings. Especially small and medium scale operations contribute to this local production of resources. By increasingly producing, reusing and recycling that which the city needs within its limits, Berlin reduces its ecological footprint while creating economic opportunities.

The Accessible Berlin revolves around the city's capacity to provide access to infrastructure, services, public space and opportunities regardless of a person's age, gender, religion, origin, sexual orientation, etc. This accessibility in the widest sense is provided by public services and policies as well as by private initiatives and individual actions. An important aspect of this accessibility is the principle of using instead of owning. This refers to concepts like the sharing economy as well as to public services (public transport instead of private car, public park instead of own garden). By providing accessibility, Berlin makes it possible for its inhabitants to live and act sustainably.

The three profile areas form a union and complement each other. It is in the combination of these three fields that in Berlin already today sustainability is being practiced. And the Berlin Sustainability Profile points at where and how the city might become even more sustainable in the future. However, even though the profile areas work as three pieces of a union, each of them integrates social, economic and ecological aspects. Furthermore, the individual profile areas are not limited to specific policy areas. Each topic of sustainable development in the city can be seen through the lens of each of the three profile areas.

The example of urban gardening might be seen through the lens of the BSP as follows. In the Enabling Berlin people try out and experiment with forms of guerilla gardening, in the Productive Berlin a collective garden, or urban farm produces food and/ or recreational value for the gardeners involved and in the Accessible Berlin the city administration regulates the fair access to gardening areas through an allotment gardening policy. The policy field of housing in each of the profile areas could be seen as follows. In the Enabling Berlin different actors experiment with new forms of living together e.g. through a joint building venture. In the Productive Berlin housing cooperatives and other developers construct low energy dwellings. In the Accessible Berlin high quality social housing ensures a social mixity also in inner city neighbourhoods.

4.3_How the Berlin Sustainability Profile was created

The Berlin Sustainability Profile was constructed over a time span of slightly more than one year, with the main work undertaken in 2015. The expected publication date is in 2016. The Senate Administration for Urban Development and Environment was supported in the creation of the BSP by the European Secretariat of the global city network ICLEI, the Berlin based research institute IZT – Institut für Zukunftsstudien und Technologiebewertung (Institute for Futures Studies and Technology Assessment) and the communication and moderation agency Suedlicht. Furthermore, for the duration of the process, a group of experts served as an external advisory council. During the course of 2015, the project team undertook a number research steps and went through a number of feedback loops that informed the creation of the BSP.

The first step was an analysis of 23 central plans and strategies for urban development in Berlin, ranging from policy areas such as housing, climate change, energy, to areas such as creative economy, cycling or public space planning. The aim was to find qualities of sustainability as well as overlaps between these different documents. The analysis was undertaken along the line of a number of criteria such as priorities within the strategies, macro trends and problem definition referred to, aims, actors, relation to sustainability, etc. Furthermore, a number of interviews were conducted to complement the document analysis and to possibly capture attributes of a Berlin specific approach to sustainable development that could not be identified in the official documents. The interview partners were firstly, experts on urban development and sustainability from outside Berlin that provided an outside and comparative view on the city. Secondly, actors living and working in Berlin that are not directly working with the concepts of urban development and sustainability, therefore providing a grass-roots and “laymen’s view” on the topic.

The results and conclusions of these research steps were discussed and put under scrutiny in an online survey and a stakeholder workshop. Participation in the online survey was on invitation only. The recipients of this invitation were actors in Berlin that work with sustainability on a daily basis, such as researchers and civil society groups. The survey asked for feedback on the profile areas and for projects that could illustrate the profile areas on the ground. The stakeholder workshop assembled important actors in the field of urban development, regardless of their connection to the topic of sustainability. Feedback was collected on the overall approach of the BSP, the profile areas and possible, or already existing expressions of the profile areas in the city.

5_Discussion

At the time of this publication, no experience could yet be gained with regard to the implementation and operationalization of a local sustainability profile. The Berlin Sustainability Profile, which is the first of its kind, will only be published in course of 2016. Still, there are a number of arguments and questions that need to be addressed. Some reflect on the creation process of the BSP and local sustainability profiles in general, others anticipate the upcoming implementation of the BSP and learning effects that might possibly be gained for other local sustainability profiles. Many of the points raised below came up in the discussions and comments of the stakeholder dialogue, the online survey and the expert group meetings which informed the creation of the BSP.

An advantage of the approach of a local sustainability profile seems to be a focus on talents and strengths of a city. Existing sustainability strategies tend to set up a task list of actions that should be implemented in order to achieve certain aims. They therefore focus more on "what should be done" and less on the "how should something be done". Mintzberg and Waters (1985) for example claim that strategy is "a pattern in a stream of actions". A strategy is therefore not a predefined task list that needs to be implemented, but rather a direction for one's actions that emerges and unfolds over time. The profile areas of a local sustainability profile identify this direction and offer paths to travel on.

However, moving away from clearly defined tasks to broader profile areas makes it more challenging to identify which policy fields are concerned and therefore which municipal departments should be involved in the implementation. The Berlin Sustainability Profile for example focusses its profile areas in the field of urban development as its task is to elaborate on the dimension of sustainability in the city's urban development strategy. Yet, the three BSP profile areas, as described above, might not only be limited to urban development. For example, the profile area Productive Berlin, despite clearly having relevance for urban development, might also touch policy fields such as education: if a city aims to be truly resource productive and efficient, it might need a work force which is sufficiently trained and educated for such challenges. Therefore, while the BSP, created by and for a specific Senate administration, deliberately limits itself to urban development, it might easily be extended to other policy fields of the city.

There seems to exist a consensus that a city will not become sustainable solely based on the actions of public authorities alone. Also businesses, academia and civil society can significantly contribute to sustainable urban development. However, this raises another question regarding the boundaries of a local sustainability profile. When asking what the strengths and talents of a city for sustainability are, does that only refer to the talents of the municipality, or are also other actors referred to? The BSP for example has a very strong focus on the city administration's role in urban development. This can be seen in the creation process, which places a strong emphasis on the analysis of municipal strategies. In the case of the BSP this seemed a reasonable approach. Yet, how would the identification of strengths and talents for sustainability look like, that places more emphasis on non-public actors and how would profile areas look like, that take into account more actors?

One of the cornerstones of the design process for the Berlin Sustainability Profile was the analysis of key documents and strategies for urban development. This analysis was the first step in identifying the sustainability talents of the city. The results were critically examined and profile areas carved out, that offered development potential for the future. This approach proved productive in the work process and was identified as a necessary precondition for a successful application of the BSP later on. Still it poses some questions. How instructive are municipal strategies, some of them already in place for several years, for identifying and anticipating future trends and challenges? Furthermore, how open for change and innovation, how adaptable will a local sustainability profile be that is rooted so strongly in already existing plans and strategies? Additionally, how will be the relation between the sustainability talents identified in a local sustainability profile and counterproductive obstacles for sustainable development? What will be the driver of change: identifying weak spots or focussing on talents - or can both be consolidated in a constructive way?

A reoccurring question during the creation process of the BSP concerned the possibility to measure the performance of the profile areas. This seems a reasonable demand since policies, programs and projects need to offer possibilities to evaluate them after a certain time in order to determine their effectiveness. However, indicators and quantitative measurement do not seem practical tools for evaluating local sustainability profiles. In the case of the BSP it is not the primary aim to make the city more productive, enabling or accessible, which could possibly be measured quantitatively. The idea is that by making Berlin more productive, enabling and accessible in the sense of the profile areas, the city is becoming more sustainable. Therefore, two things can be measured: first, through (possibly already established) quantitative indicators it can be measured if a city becomes more sustainable while employing a local sustainability profile. Second, through a qualitative process evaluation it can be evaluated how well a local sustainability profile with its profile areas contributes to reaching the sustainability aims of a city.

Related to the question of measuring the impact of a local sustainability profile is the question of how impact is actually created through a local sustainability profile – or, in other words: how is a local sustainability profile implemented. Above we explained that a local sustainability profile should support a city in its sustainability efforts with few, or no additional resources. This will be achieved because a LSP allows a city to focus its activities on areas that will make it more sustainable. It is based on the assumption that in order to achieve sustainability a city does not always need to spend more money, but should rather reconsider and prioritize the money it spends anyway. This of course makes it necessary that the actors in charge of allocating resources are either convinced that the pathways offered by the profile areas will be beneficial, or ordered into reallocating their resources towards them nevertheless. Since a coercive method does not promise a high success rate, it is paramount that a LSP establishes a convincing narrative. The most important skill for the implementation of a LSP is therefore communication, in order to convince relevant actors to come on board.

6_Conclusion

This paper set out to provide answers to the questions what is a local sustainability profile and how can sustainability profiles contribute to sustainable urban development? It claimed that sustainability profiles are a noteworthy new approach to local sustainability strategies and could contribute to local sustainability governance also in other cities.

By describing the status quo of local sustainability strategies and the challenges faced by many cities, this paper provided a background against which the idea of a local sustainability profile was developed. In a short introduction the underlying idea behind the concept Local Sustainability Profile was elaborated on and a few characteristics for the development of a LSP were suggested. Furthermore, the case study Berlin Sustainability Profile was described as the first application of this new concept. More concretely, a short introduction into the history of sustainability efforts in Berlin was given, followed by a presentation of the content of the BSP and the development process.

It was discussed how the profile areas of a LSP, such as the ones developed in Berlin (Enabling Berlin, Productive Berlin and Accessible Berlin) can allow a city to focus and prioritize its efforts and become more sustainable with limited resources. This paper also discussed the vital role of communication, which is expected to contribute largely to the success of a LSP. Furthermore, it was discussed how, based on the experience in Berlin, LSPs might also be developed and used in other cities and different contexts. Finally, it was claimed that a focus on the strengths and talents for sustainability that a city has might add a fruitful new perspective on local sustainability management.

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ENERGY SECURITY SCENARIOS OF FUTURE EUROPE

Upscaling pioneer experiences in a low carbon context

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Abstract

Energy security has become a policy priority for the European Union due to growing concerns about environmental challenges and the fact that the EU imports about half of its energy needs. In particular, the EU is dealing with climate policy and energy security jointly: both the Climate and Energy Package and the Energy Roadmap 2050 endorse the goals of reducing greenhouse gases emissions while at the same time ensuring security of energy supply. However, low-carbon transition and energy security are not always faces of the same coin. As a matter of fact, successful policies aiming at the former may undermine the conditions at the basis of the latter, and vice versa. Developed in the framework of the MILESECURE-2050 FP7 project, the proposed contribution explores the impact of societal processes and various policy mixes aiming at energy transition towards a low carbon economy, in view to provide a better understanding of aspects and potential trade-offs for energy security in Europe. It presents the results produced through IMACLIM-R, a model allowing for the integration of innovative dimensions as the urban form, transport dynamics, environmental policies and human behaviours. Building on the study of a set of local good practices, the contribution introduces three scenarios presenting different assumptions on the energy transition and the implementation of climate policies. This paper demonstrates the positive macroeconomic outcomes of combining societal processes with transport dynamics in energy transition scenarios and specific macroeconomic policies.

1_Introduction

Energy security has recently become a policy priority for the European Union (EU) due to growing concerns about environmental challenges (in particular climate change) and the fact that the EU imports about half of its energy needs. Energy security is also a polysemic concept focusing on limiting the risk of internal and external energy shocks. Gracceva and Zeniewski (2012 p10) define an energy secure system as one *evolving over time with an adequate capacity to absorb adverse uncertain events, so that it is able to continue satisfying the energy service needs of its intended users with 'acceptable' changes in their amount and prices*. This does not necessarily imply a reduction of emissions and an increase in the use of sustainable energy sources, issues that lay at the heart of the energy transition towards a low carbon society. Furthermore, low energy and carbon transition implies to envisage significant bifurcation in lifestyles not only triggered by the penetration of a range of low carbon technologies into society but also by the change of personal and collective behaviors, an assumption that add further complexity to the picture.

Aware of the above discussion and these challenges, this contribution envisages the interactions between climate policies and energy security issues through the lens of a methodological approach developed within the framework of the MILESECURE-2050 FP7 project[1]. In particular, it brings forward some of the results of the project, by developing new European scenarios using multiple perspectives which support and enable energy security. The three scenarios proposed were developed through the IMACLIM-R model, building on a

set of narratives that takes into account the societal processes and changes in human behaviors analyzed during the project[2]. A specific focus is dedicated to the implications in terms of transport dynamics and urban forms that are key issues for the climate and energy security issues (Sims et al., 2014).
Section 2 of the paper presents the narratives developed on the analysis of societal processes conducted in the MILESECURE-2050 project, and introduces the three scenarios. Then, section 3 describes the IMACLIM-R model and its specificities more in details. Section 4 presents some key implications of these scenarios in terms of energy security and low carbon transition.

2_From narratives to scenarios

2.1_Elaborating energy transition narratives based on pioneer initiatives

One of the main steps of the MILESECURE-2050 project consisted in analyzing drivers and barriers of the energy transition on the basis of a range of so called local "anticipatory experiences" or pioneer initiatives[3]. This range includes a large number of concrete experiences at the local level, collected throughout Europe and already experiencing a low carbon transition (or, at least, some of its features) and having specific characteristics compared to other sustainable energy initiatives (operationality, social impact, transparency, systematicity) (Caiati et al., 2013; 2014).
The analysis of these experiences reveals some salient features of societal processes in the energy and low carbon transition that were used to guide the building of the scenarios, mainly through technical adjustments of the IMACLIM-R model (see Section 3). More in detail, these societal processes are at the basis of multi-dimensional changes regarding development pathways: this affects individual or collective behaviors, types of energy use and production and governance modes. Drivers of the underlying changes of these experiences are not only technology oriented but also, and often more relevantly, based on social dynamics (Caiati et al., 2013).
After a thorough analysis of the qualitative information collected through the set of pioneer experiences, it was possible to identify three key societal dimensions of the low carbon transition, that were then used to structure the narratives of the scenarios (see Figure 1). The **first dimension** relates to the governance of the energy systems. The choice between centralized and decentralized energy production systems is a key challenge of the low energy and carbon transition.

[1] The present paper is indeed based on the results of the FP7 Project MILESECURE-2050: Multidimensional Impact of the Low-carbon European Strategy on Energy Security, and Socio-Economic Dimension up to 2050 perspective (www.milesecure2050.eu). The MILESECURE-2050 consortium is led by Politecnico di Torino (Italy), and composed by ten project partners: Instytut Energetyki IEn (Poland) EnergSys (Poland); ENEA (Italy); Laboratorio di Scienze della Cittadinanza LSC (Italy); Maastricht University MUSTS (The Netherlands); The University of Salford USAL (United Kingdom); Paris-Lodron Universitat Salzburg – PLUS (Austria); EU Joint Research Centre JRC (EU); Ecologic Institute (Germany);– SMASH (France).

[2] These scenarios have been developed in collaboration with Instytut Energetyki IEN (Zygmunt Parczewski) and Energsys (Adam Umer, Marek Niemyski). In this paper, only part of the modeling results of the project focused on the IMACLIM-R model are considered (see Parczewski et al., 2015 and Cassen et al., 2015).

[3] 90 experiences from 19 European countries already experimenting, at least partially, energy transition processes have been assessed according to a set of criteria such as type of actions, anticipatory awareness, visibility, types of energy involved, sources of funding, and replicability were considered (Caiati et al., 2013, 2014).

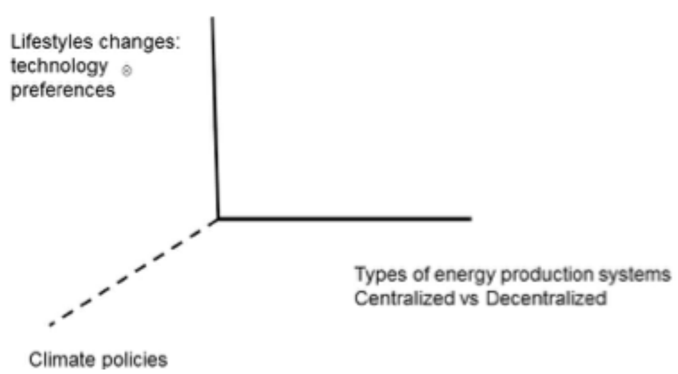

Figure 1. The three key dimensions of energy transition scenarios (Source: Authors' own elaboration).

In recent years, a range of factors have opened a window for debate about the degree of centralization of the energy system in Europe (Crivello et al., 2013; Nadaï et al., 2015): new energy technologies (smart technologies, distributed energy production technologies) and local low carbon experiments are emerging; liberalization has opened the electricity market and sector to new entrants and the EU climate energy policy has supported the integration of Renewable Energy Sources (RES) technologies. These factors paved the way for the emergence of a heterogeneous set of innovative local experiences in the climate and energy field that partly underline pioneer experiences in energy transition.

The **second dimension** relates to the content of development pathways, either technologically driven or marked by radical changes in preferences. On one extreme of the spectrum, the energy transition is characterized by the development and the penetration of low energy and carbon technologies but with limited changes in the demand side. On the other extreme, the transition is driven mainly by changes in the demand side, such as those described in the case of societal processes that underline pioneer experiences. The main components of the changes in demand patterns are the use of new types of energy modes, particularly at the urban level (soft modes like biking, walking, involvement in energy communities etc…) that will also impact the types of energy carriers, infrastructures, institutions and regulation.

A **third dimension** structuring the narratives deals with institutional and geopolitical issues, in particular with the climate policies that accompany the transition towards a low carbon society.

2.2_Introducing the three scenarios

2.2.1_The No Emission Regulation scenario (*NER*)

The *NER* scenario represents a prospect for the future without efforts to support the low energy and carbon transition. Regarding the three dimensions identified above, there is no significant change in the energy production systems (no bifurcation towards one specific model), people's behaviors and consumption styles, limited penetration of low carbon technologies and no climate policies. This scenario is used as a benchmark for the other two.

2.2.2_The Conventional Energy Transition scenario (*CENT*)

The *CENT* scenario features a centralized energy transition for Europe and its Member States, mainly driven by technologies and the implementation of large interconnection projects. Incentives for innovation at the local level are relatively low as R&D efforts are directed mainly to the development of large-scale technologies (RES, cross-border networks etc.). Similarly, the scenario does not assume relevant changes in people's lifestyle; the development of human energy is particularly limited. Both top-down political and technically features of this scenario delay the involvement of local communities in participation processes regarding energy transition issues.
In a geopolitical context marked by the Paris Agreement (UNFCCC, 2015), the EU applies its own climate objectives that consist in a reduction of the CO_2 emissions of -20%, -40% and -80% respectively in 2020, 2030 and 2050

(compared to 2005 levels) (EU, 2011, 2013). The scenario assumes that other countries will apply their pledges within the framework of their own INDCs[4] which is currently insufficient to comply with the 2°C target[5].

2.2.3_The Social Energy Transition scenario (*SET*)

Contrary to the *CENT* scenario, the Social Energy Transition (*SET*) scenario features a decentralized energy transition mainly driven by changes in lifestyles and in governance modes, in particular at the urban level. It assumes an increase in the development of local communities, grass-roots initiatives, participation processes of decision-making concerning energy transition. This gradually impacts the content of the regulations that increasingly favor the development of energy transition in the direction of micro and small low carbon energy solutions. Strong efforts are also implemented to develop green infrastructures, particularly as regards to rail transport in passenger and freight, and public transport in cities. More generally, public infrastructures at the regional and local level are increasingly modernized. The same types of climate policies are also assumed than in the *CENT* scenario.

3_A modelling framework to simulate energy transition pathways

3.1_Modeling framework and methodology

IMACLIM-R (IMpact Assessment of CLimate Policies) is an Energy-Economy-Environment (E3) model based on a hybrid modelling framework (Hourcade et al., 2006). The model is built to facilitate and allow the dialog between engineers and economists and also aims at integrating other dimensions (such as the urban form, environmental policies, human behaviours etc…) that enables a broader pluridisciplinary dialog among the scientific communities (e.g. sociologists, geographers, political scientists…). It also allows for transitory partial mis-adjustments of the economy triggered by the interplay between choices under imperfect foresight and inertia of technical systems.

3.2_A focus on the transportation sector: a way to include energy consumption and urban organizations

Part of the societal processes described in the previous section are represented through an important vector that is linked to territorial and urban zoning policies, as well as to issues related to energy consumption, namely the transportation sector. This is also a key issue to consider when dealing with bifurcation in lifestyles (SIMS et al., 2014).

IMACLIM-R proposes a framework that helps disentangling the role of transport in long-term socio-economic trajectories and the potentials offered by specific measures on these sectors to face fossil fuel depletion issues as well as emissions mitigation costs. IMACLIM-R includes a stylized representation of 'behavioural' determinants to explicitly represent the interplay between transportation, energy and growth patterns (Waisman et al., 2013)[6]. The advantage of IMACLIM-R is that it joins both dimensions with a macro-economic closure, thus ensuring a robust assessment of the challenges posed to the economy by energy security and climate change issues.

In IMACLIM-R, passenger daily mobility and the transport intensity of production are defined by the spatial distribution of housing, transport and

[4] At the Conference of the Parties (COP) at Warsaw all Parties to the United Nations Framework for Climate Change Conference (UNFCCC) were invited to communicate for COP 21 in Paris their own mitigation strategies and targets. So far, 186 parties representing 99% of the emissions have submitted their INDCs.

[5] Since the Cancun conference in 2010, limiting the 2°C increase of the average world temperature is an official objective of the climate negotiations.

[6] This is a real added value, since most modelling tools are mainly based upon sectoral approaches that have either a 'technology-based' or a 'behavioural-based' nature (Sims et al., 2014).

[7] "Public transport" includes both urban public transports (buses, metros… etc.) and inter-city trains, as the model does not differentiate between inter- and intra-city trips.

[8] The reader can refer to some detailed descriptions of IMACLIM-R that contains more detailed technological descriptions: i) the model description Wiki produced as part of the EU FP7 ADVANCE project: https://wiki.ucl.ac.uk/display/ADVIAM/Home; ii) the supplementary online material (Hamdi-Cherif and Waisman, 2015).

industrial infrastructures. In addition, important stylized facts are captured: i) *The modal distribution between different modes:* terrestrial public transport[7], air transport, road transport (private vehicles) and non-motorized transport (walking and biking); ii) *The rebound effect on mobility due to energy efficiency improvements*; iii) *The induction effect of infrastructure deployment on mobility demand*: for a given transportation mode, the deployment of new additional infrastructures increases the capacity of the corresponding network and decreases the congestion constraint. The freight mobility representation captures implicitly i) *The spatial organization* of the production processes in terms of specialization/concentration of production units; ii) *The constraints imposed on distribution* in terms of distance to the market and just-in-time processes.

Applied to the aforementioned scenarios, *CENT* considers no changes in investment choices driving mobility demand with respect to those implemented in *NER*. Constrained mobility evolves proportionally to total mobility in order to *(i)* take into account all basic mobility purposes – such as commuting, shopping and access to services – and *(ii)* have a proxy of the increase of urban sprawl as households gain better access to transport modes with increased performance. The allocation of investments in transportation infrastructures follows the increase of mobility demand of each transportation mode (e.g. the more pkm are satisfied by private vehicles, the more roads will be constructed). The organization of production/distribution processes remains similar throughout the period, which means that the freight transport intensity of production keeps constant.

In *SET*, the carbon pricing policy is complemented by measures to change the 'behavioural' determinants of transport in the course of the low-carbon transition (both directly and indirectly), which is a way to implement some important features of the societal processes included in grass-root initiatives. The model includes in a very synthetic way spatial planning policies and changes in investment decisions for long-lived transport-related infrastructures. More precisely, it is assumed: i) a progressive reduction of households' basic mobility from 50% of total mobility in 2020 to 30% in 2050 and after. This represents a spatial reorganization at the urban level (more dense cities) and the implementation of soft measures towards less mobility-dependent conglomerations ii) shifts in the modal structure of investments in transportation infrastructures favouring public modes instead of private vehicles (Waisman et al., 2013) iii) reorganizations of production/distribution logistics inducing a decrease of freight transportation needs (e.g. improved back loading, more space-efficient packaging, shorter or more transport-efficient ordering cycles, etc.). *SET* is at least much more optimistic with higher availability (lower costs and higher potential) of low-carbon technologies that are considered than *CENT*. Indeed, the upscaling of pioneer experiences the obstacles to the penetration of low carbon technologies [8].

In order to highlight the specific impact of macro-economic policies to trigger a low energy and carbon transition, both scenarios assume that a renegotiation of the social contract has occurred based on a recycling of a carbon tax into lower payroll taxes and a redirection of savings towards low carbon investments instead of liquid assets or real estates.

4_Results

4.1_Macroeconomic impacts for EU28

Table 1 indicates persisting macroeconomic costs over the period in *CENT* compared to *NER*. The benefits of the recycling of carbon taxes are outweighed by the increase in households' energy bill and production costs of industry due to a growing value of carbon prices as shown in Table 2. As dynamics of the energy demand do not change, capital-intensive low carbon investments are necessary that also impact the overall cost of the low carbon transition. Furthermore after 2030, to reach the high-cost mitigation potentials in the transportation sector requires maintaining efforts to reduce emissions based on a steep increase in carbon prices if there is no specific effort on the mobility demand (Waisman et al., 2012). These macroeconomic costs start declining after 2040 thanks to induced technical change.

	2020	2030	2040	2050
CENT	-3,0%	-6,4%	-6,2%	-4,9%
SET	-0,3%	-0,2%	-0,5%	1,1%

Table 1. GDP variations with respect NER with recycling of carbon tax and climate finance mechanisms (EU28).

	2010	2020	2030	2040
CENT	0	140	249	984
SET	0	101	134	756

Table 2. European CO_2 prices (t/CO_2).

SET generates near positive outcome between 2010 and 2020 thanks to the stimulating effect on growth of higher investments in green infrastructures and to lower labor taxes. These benefits are outweighed after 2020 by the increase of carbon energy prices. However, GDP losses are far lower than in *CENT* because: i) the carbon tax is one third below compared to *CENT*; ii) behavioral changes make the economy less dependent on energy costs. These losses start decreasing after 2030 and are almost negligible (0.5 variation in GDP growth rate in 2040). After 2040, the scenario generates a positive GDP outcome thanks to technical change and the joint deployment of pioneer experiences at a local level and the early support to low-carbon infrastructures by governments and cities as defined in *SET*. *SET* thus represents a no regret scenario which could be pursued because of its benefits in terms of energy security and avoided climate change damages. It demonstrates that mobilizing human factors into innovative local initiatives and changes in lifestyles are necessary to achieve a low carbon transition with no social costs in a world where Europe (EU28) acts almost unilaterally. A broader estimate of other potential co-benefits beyond energy security, in particular health improvement resulting from the reduction of pollution, preserving biodiversity through limiting urban sprawl...) may also reduce the remaining social and economic costs observed in our simulations albeit potential adverse side effects (e.g. rise in rents as a result of more compact cities)[9].

[9] Bollen, (2015) show that the value of the co-benefits in terms of improvement of air pollutant gases (SO2, NOx, and PM2.5) could attain 10-20% of the mitigation costs in EU27 during the period 2030-2040.

4.2_Impact of scenarios on energy security parameters

4.2.1_The dependence dimension

Table 3 indicates that in *NER*, the share of energy import bill over GDP increases continually until 2030 reaching 4.6% and then starts to decrease until reaching in 2050 almost the same level than the one of 2010. The same trends are observed for *CENT* and *SET* until 2020. Then this share starts to decrease significantly, reaching 1.8% in 2050 for *CENT* and less than 1% for *SET*. Indeed, after 2020, as the result of the implementation of the carbon tax, the decarbonisation of the economy is well underway and is much less dependent on fossil fuel energies. The share of energy imports expenditures is significantly lower in *SET* highlighting higher improvement in energy efficiency, stronger penetration of RES and less energy intensive urban forms.

Table 3. Energy imports bill/ GDP for Europe (Author's own elaboration).

	2010	2020	2030	2040	2050
No emission regulation (Ner)	3,1%	4,1%	4,6%	4,0%	3,4%
CENT	3,0%	4,2%	3,9%	2,6%	1,8%
SET	2,9%	3,4%	2,9%	1,7%	0,8%

4.2.2_The affordability dimension

While the share of energy expenditure in households' budget remains almost constant by 2050 in *NER* it increases between 2010 and 2020 in *CEN* and *SET* and then declines by 2050 (table 4). Indeed, by 2020 the carbon tax increases the cost of energy for households. The decline is then much stronger in *SET* than in *CENT* (7% vs 11% in 2050 as illustrated in table 4) in a context, as mentioned above, in which the carbon price is much lower than in *CENT*. The share of energy expenditure in 2050 is also lower in *SET* than in *NER*.

Table 4. Share of Energy in Households' Budget for Europe (Author's own elaboration).

	2010	2020	2030	2040	2050
No emission regulation (Ner)	9%	10%	10%	9%	9%
CENT	9%	16%	14%	14%	11%
SET	9%	12%	10%	9%	7%

This outcome is a direct effect of the assumptions made on the demand side regarding urban planning policies and transportation infrastructures measures in SET that play a key role in terms of energy consumption. They imply twofold consequences: a relative shift in terms of transportation modes toward more low-carbon public transport modes and a decrease of mobility needs as a result of a reorganization of urban infrastructures. The passenger mobility satisfied by personal vehicles (pkm) are also almost two third lower in SET compared to NER in 2050 as shown in Figure 2.

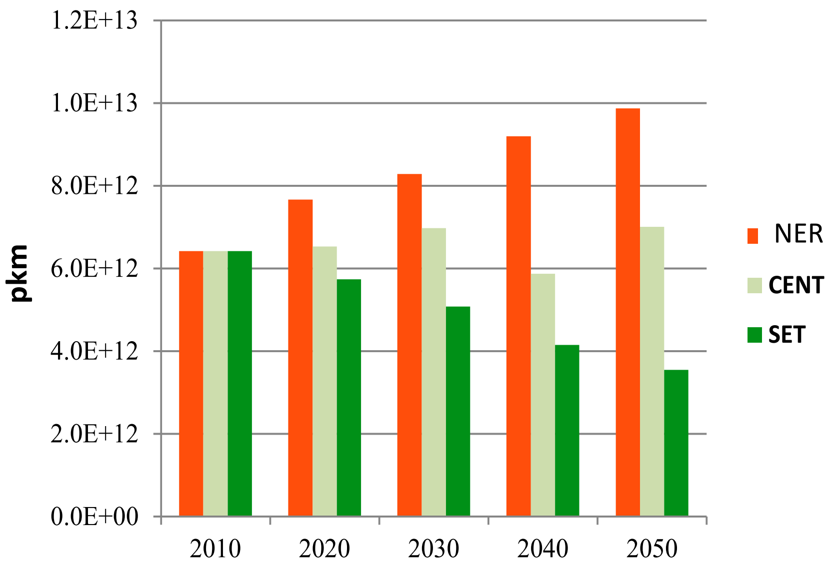

Figure 2. Mobility satisfied by personal vehicles (pkm).

4.2.3_Impacts of energy shocks on the results

This section simulates some important shocks that occur in the oil and gas market. They correspond to a hypothetical case of geopolitical tensions with Middle East and Russia. Oil and gas markets production capacities are respectively cut by 10% each year from 2030 to 2035. In 2030 this shock induces a significant increase of the oil price (+85% with respect to the situation without shock as shown in Table 5). Indeed the economy is not prepared to face such a shock and the oil demand is still important while the supply is suddenly cut. Although the economy starts to gradually adapt being less oil dependent, Table 5 showing a reduction of the price increase (from +85% in 2030 to +34% in 2035), oil prices remain significantly higher than their level without shocks (168$/bl vs 225$/bl in 2050). This illustrates the non-substitutability of the oil in the transportation sector.

2030	2031	2032	2033	2034	2035
85%	68%	46%	41%	36%	34%

Table 5. World price oil variations between NER_shock and NER.

However, the GDP in *NER_shock* comes back to the 2030 level in *NER* in less than two years (more precisely in 20 months). This means that *NER_shock* represents less than a two years delay for a continuing shock of 5 years, illustrating thus substantial adaptation and recovery capabilities of the European economy. In climate policies scenarios, as shown in Table 6, Europe also suffers from the energy shocks. GDP variations with respect to *NER* during the shock period indicate losses that are 4 to 5 points higher (respectively *CENT* and *SET*) when the shock hits the economy in 2030. Then the gap between the losses with and without shock shrinks with only 1 point difference in 2035.

	2010	2020	2030	2040	2050
Ner_shock	9%	10%	10%	9%	9%
CENT_shock	9%	16%	14%	14%	11%
SET_shock	9%	12%	10%	9%	7%

Table 6. GDP variations with respect to the NER scenario.

[10] This political agenda partly connects to the Paris Agreement that calls "to explore ways of enhancing the implementation of training, public awareness, public participation and public access to information so as to enhance actions under the Agreement" (UNFCCC, 2015, para 84).

The small magnitude of the macroeconomic impacts generated by the energy shocks is due to the fact that the economy has already experienced an increase in energy prices before, due to the introduction of a carbon price and thus already started to decarbonize. The shock arises when the fossil fuel consumption is low and then does not have a serious impact on the economy. *SET_Shock* is more resilient mainly because less transportation activities lowers the demand for fossil fuel.

5_Discussion and conclusion

Outcomes from the IMACLIM-R model demonstrate the importance for Europe of supporting the development of changes in behaviors triggered by pioneer experiences by combining policy and measures including the deployment of green infrastructures, a renegotiation of the social contract based on specific fiscal reforms and measures to secure funding of the diverse initiatives at different scales, as in *SET*. This scenario also reveals more resilient faced to significant energy shocks that result from geopolitical tensions on the oil and gas sectors and in a transitory period where the economy is not entirely decarbonized. In terms of policy implications, these results argue in favor of integrating the role of human factors in energy and climate policies that support changes in behaviors in particular through transport and urban infrastructures[10]. Further improvements could include in IMACLIM-R broader changes in lifestyles and behaviors (circular economy, potential changes in the food diets and production at the local level, increase role of smart grids or innovative forms of energy production). Coupling our results with urban models developed at CIRED such as NEDUM (Viguie et al., 2014) or GEMSE-FR (Faucheux, 2015) that are able to assess the impact of public policies and changes in behaviors on urban forms and visualize them are also envisaged for Europe and beyond.

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THE BERLIN WATER CONSUMER STOCK OWNERSHIP PLAN

Maintaining a clean Spree

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Abstract

As many large cities across the world Berlin is situated along a river, the Spree. What regularly causes massive fish death is not emission-intensive industries or citizens illegally disposing of waste. During heavy rainfalls as the sewers threaten to become overburden the combined sewage system discharges its contents directly into the river to prevent an overflow into the streets, a problem common to countless metropolitan regions.

The measures implemented by the city of Berlin to date – underground concrete basins as buffers and an intelligent canal control system – remain insufficient to capture the 3 to 4 million cubic meters of untreated wastewater still discharged into the river each year. LURITEC, a new system of pre-manufactured, modular synthetic glass fibre tubes that are placed in the river instead of underground can make a cost-efficient contribution towards closing this gap complementary to traditional concrete tanks.

Two major obstacles so far hindered implementation of the 60 million Euro LURITEC project: Firstly, a lack of financing; secondly, a lack of political support. Here citizen's financial participation can lower public costs while providing a grassroots democratic backbone. A Consumer Stock Ownership Plan (CSOP) allows for low-risk loan financing of a significant share of the project while at the same time requiring only a small financial contribution from the CSOP participants. Combining different revenue sources the redemption period for repaying the 12.4 million Euro debt is 8.5 years.

1_Introduction – Problem description

Many large cities in Europe and elsewhere are situated on rivers or other sizeable bodies of water – lakes, canals, bays, and channels. However, as a rule, they do not serve urban residents as amenities enhancing the quality of life as they mostly are too filthy, too polluted and too ill-smelling to swim in, boat on, picnic near or otherwise enjoy[1]. Berlin's River Spree is a case in point. Although Germany has greatly improved surface water quality over the last decades, and the Spree is swimmable on the outskirts, the river and its subsidiary streams within the city are periodically contaminated when heavy rainfall overwhelms the municipal sewage system and, in order to protect the streets, the overflow, including raw sewage, is diverted into the Spree[2]. Given the river's weak current, the effects of these overflows last for weeks. The enriched mix of toxic substances, bacteria and nutrients is a threat to both human and aquatic life (Federal Ministry for the Environment, 2013). Oxygen deprivation results in massive fish deaths (Berlin House of Representatives, 2013), as last occurred on June 8, 2015[3]. As in many other cities, it is thus not years of industrial exploitation and neglect or illegal dumping of waste that periodically deteriorates the water quality but the city's sewage system itself.

2_Conventional Solutions

The city of Berlin has long tried to deal with this problem by constructing underground concrete basins as buffers and by introducing an intelligent canal control system.

[1] This is not a given as the example of the city of Munich shows. In far-reaching, costly measures the river Isar was renaturalized, today swimming and aquatic sports are core features of urban life; see http://www.muenchen.de/freizeit/sport/surfen.html.

[2] Berlin as most large cities features two types of sewage systems: in the city centre rain and wastewater are jointly collected and lead on to the nearest treatment facility in a combined system; in the outskirts rain and wastewater disposal are separated.

[3] See: TAZ of 15 June 2015 *Environmental problem sewage system – heavy rain pollutes Landwehr-channel.*

In 1998 an action plan was put together to invest EUR 157 Mill. – split 60/40 between the state of Berlin and the Berlin Water Works – to reduce by half the "mixed sewerage overflow" by 2020 (Berlin House of Representatives, 2015 a)[4]. In early 2015, the Berlin Senate announced a long-term goal of making all surface waters connected to the city centre's combined sewerage system swimmable (Berlin House of Representatives, 2015 d). An eventual 310,000 m³ of buffering space is to be built, of which 230,000 m³ has been completed so far, according to the Senate administration for city development and environment.

The techniques applied – all underground – are based firstly on concrete buffering tanks and secondly on intelligent canal management which re-channels sewerage through weirs and throttles (intentionally designed bottlenecks) within the approximately 2,000 kilometres of the canal network[5]. Since 2012 the water management system has been partially automated by a so-called "Guide and Information System" ("Leit- und Informationssystem" LISA), which utilizes the coping potential of the city's vast canal system: Since no given rain event affects the entire city equally, the lighter or unburdened areas can function as an inexpensive buffer, adding up to 220,000 m³ at the relatively modest average cost of €500 per m³. The much more expensive underground concrete tanks cover only a fraction of this[6], so buffering an additional 35,900 m³ at an average cost of EUR 4,100 per m³ (for details see Section 9 below) is extremely cost-ineffective; yet when added up falls far short of that required to neutralize the roughly 3 to 4 million cubic meters of untreated wastewaters discharged into the river each year (Berlin House of Representatives, 2015 c).

3_Summary of the Complementary "LURITEC System"

The "LURITEC System" designed by the Berlin based LURI.watersystems. GmbH engineering firm could make a significant but cost-efficient contribution towards closing this gap in buffering space. Pre-manufactured, modular synthetic glass fibre tubes replace traditional concrete tanks and these are positioned in the river itself rather than underground (Figure 1)[7]. In cities like Berlin where wastewater treatment as such is not a problem the LURITEC System provides an additional buffering cushion for sewage overflow during heavy rainfalls. Once water levels recede, the tank contents are rechanneled into the sewage system to be treated normally.

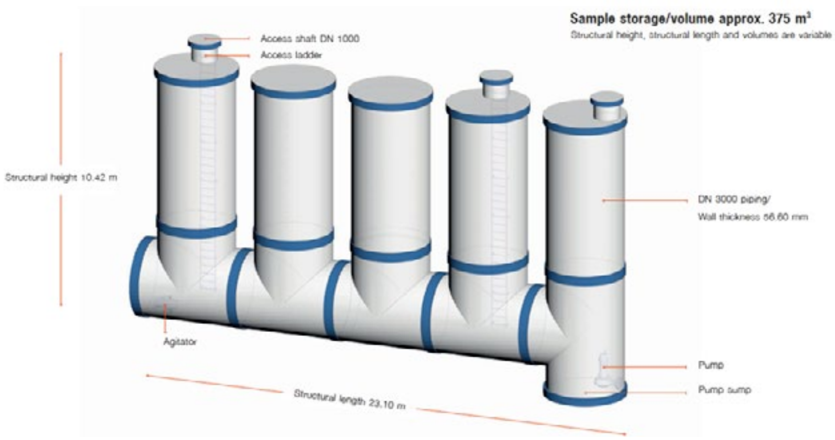


Figure 1. A LURITEC Plant as a combination from vertical and horizontal tubes. Source: LURI. watersystems.GmbH.

[4] As strategic target the Berlin Senate stated "to achieve a mid- to long-term reduction of emissions (AFS, heavy metals, PAK, TP) by 50% through a consequent realization of decentral, semi-central as well as central measures for a physical rain water treatment".

[5] Current and planned projects so far are: a throttel in Modersohnstraße (EUR 1.6 Mill., expected completion: 2015), adjustable weir and bypass canal Bornholmer Straße/ Swinemünder Straße (EUR 3.4 Mill., 2016), buffer canal with pumping station Mauerpark / Schwedter Straße (EUR 6.9 Mill., 2018), rain water buffer Sophie-Charlotten-Straße (EUR 4.5 Mill., 2020) and rain water buffer Chausseestraße (next to the BND, EUR 30 Mill., 2021) – the largest project encompassing 17,000m³.

[6] According to the Federal Statistics Bureau (Fachserie 19 Reihe 2.1 *Umwelt, Öffentliche Wasserversorgung und Abwasserbeseitigung* Wiesbaden 2003) in 2001 basins with a total volume of 26.000m³ existed; from 2003 to 2014 a total of 9.900m³ was added.

[7] The high-strength composite material consists of reactive resin, non-swellable quartz sand and integrated glass fibres. A horizontal DN 3000 pipe onto which DN 3000 T-pieces are laminated serves as the base component.

[8] Directive 2000/60/EC requires to achieve a "good water quality" of surface water and groundwater from 2001 until 2015; however, the planning of measures may be prolonged until 2027 under certain circumstances; transposed into German federal law by the "Wasserhaushaltsgesetz".

However, if and when needed, the system could be equipped with modules for on-site wastewater treatment. In the initial treatment stage, mechanical sedimentation and deposition techniques are utilized, e.g., settling tanks, oil and grease skimming tanks, grills and fine sieves. In the second stage, wastewater is biologically processed, with organic substances broken down by bacteria. Appropriate techniques are also used to remove nitrogen and phosphorus. In the biological treatment stage, a number of proven technologies can be utilized, e.g, aerobic and anaerobic packed bed procedures, ABR and SBR technologies, planted soil filters ("wetlands for wastewater treatment"), and activated sludge processes.

In Berlin, preventing pollution during recurring periods of heavy rain would not just significantly improve the quality of urban life; it would also be a huge step toward meeting the European Union's recommended standards for water quality which will soon become mandatory[8]. Consequently, during a presentation before the Senate's committee on health, environment and consumer protection, Water Works chairman Jorg Simon already in 2008 (Berlin House of Representatives, 2008) considered the "LURITEC System" to be a viable addition to their repertory of possible measures.

The surface of the tanks creates an artificial island which, due to the system's modular construction, can be adapted to a variety of uses e.g., restaurant sites, recreational areas or landscaped gardens, as illustrated by Figure 2.

Figure 2. LURITEC installation in a river or lake as an element of integrated town planning. Source: LURI.watersystems. GmbH.

4_Employing a Consumer Stock Ownership Plan (CSOP) to Implement the LURITEC System

Two major obstacles stand in the way of a full-scale implementation of the LURITEC System: first is the problem of financing and second is the present lack of political support. These problems are reciprocal. The city of Berlin is unlikely to make such a financial commitment without political advocates, who in turn will be harder to convince the more costly a novel infrastructure project is. This conjunction is where citizen financial participation can be the key to lowering the cost for the public budget, while at the same time providing a grassroots democratic backbone, which makes the project politically attractive. A CSOP meets both of these requirements. It provides a low-risk loan large enough to finance a significant share of the project costs while requiring only a small financial contribution from the CSOP participants. A large-scale project like a Berlin-Water-CSOP with from ten to hundreds of thousands of participants would constitute a powerful interest group well able to argue their case in the political arena.

The classical CSOP model enables long-term consumers of utilities such as electricity and water to become co-owners of their local suppliers (Lowitzsch and Goebel, 2013). Potential CSOP participants are low-income households with few or no financial assets; households which own no productive capital and lack the savings or credit which are a prerequisite to acquiring it. The CSOP as a low-threshold financing concept opens the practice of credit financed investment – common in the business world – to the broad group of consumers who are typically denied access to capital credit. Resulting liabilities are secured by the investment and subsequently paid back from its future proceeds. When the loan is fully amortised the CSOP passes income on to participants in the form of dividends.

The LURITEC System – in contrast to conventional underground systems – is particularly suitable for the CSOP's broad constituency. Its artificial islands are a visible reminder of the public effort to keep the Spree clean. In place of technical installations looming out of the water, citizens are provided with new spaces for recreational use, for restaurants, or for just enjoying the scene as part of a new urban living quality. CSOP participants will – through their equity investment and represented by a trustee – also have a say in decisions concerning potential use of the island's surface. This anchors the citywide project in the citizenry and strengthens its democratic legitimacy, while at the same time limiting the risk of the islands being dominated by privilege in the course of on-going gentrification. Citizen capital participation thus surpasses mere co-financing, laying the groundwork for the project's acceptance and political support. Using the Berlin-Water-CSOP to finance the LURITEC System will allow all citizens of Berlin to share in the common interest of maintaining a clean river.

5_Specific Challenges for the Berlin Water-CSOP

The Berlin Water-CSOP would to some extent differ from a classical CSOP as creating a source of income for its participants would not be its primary purpose. This CSOP is envisioned as an instrument of communal and economic policy as well as a project for environmental protection. It grants its members not only participation in the decision-making process but an ownership stake in the infrastructure of their city. On the other hand, it offers only modest monetary returns (for possible long-term rewards, see Section 11 below). While the Water-CSOP will certainly generate revenues to meet its credit obligations and – following full amortization – will distribute those revenues among its participants, the large number of participants, combined with a relatively low-income profile, will allow for annual payments of symbolic size only. Given, e.g., 200,000 participants, after a redemption period of nine years the annual payout would amount to EUR 8 per participant (see sample calculations below in Section 7). But on the positive side, the project

[9] This is a classical free rider problem where a party receives the benefits of a public good without contributing to the costs; for a discussion of the problem with regard to global warming see Wagner / Weitzmann 2015.

could spectacularly improve the urban environment while actively involving citizens in the civic planning process.
However, the modest revenues themselves pose a challenge. Unlike the utility services of a classic CSOP, it is not possible to market an unpolluted river. The Spree belongs to all. A clean, publicly accessible Spree is an amenity which benefits all citizens regardless of whether they participate or not[9]. Thus, while the services of other CSOPs, e.g., energy, can be sold to individual consumers at a profit, the 'product' of the Water-CSOP – a cleaner river and better environment – cannot be promoted directly in monetary terms. Herein lies the central challenge for the Water-CSOP: Generating sufficient revenues from voluntary citizen subscribers. The Water-CSOP will need to explore alternative sources of revenue in order to re-finance its initial investment (see Section 8 below).

6_Extending the Pilot Plant to the Area "Elsenbridge-Mühlendamm sluice"

One LURITEC pilot plant has already been installed in the Berlin East Harbour to demonstrate the system's effectiveness. It has been monitored and evaluated by the Technical University Berlin for the past two years (Barjenbruch et al., 2015).

Figure 3. Waterways in central Berlin. Source: Dörrebecker, M. (2008): Karte der Berliner Wasserstraßen. In: commons.wikimedia.org. https://commons.wikimedia.org/wiki/File:Karte_der_Berliner_Wasserstra%C3%9Fen.png. Accessed: 28.07.2015.

Figure 4. Discharge points oft the combined sewage system between "Mühlendamm Sluice" and "Elsenbridge". Source: LURI.watersystems. GmbH.

In the project's subsequent phase an additional 13 discharge points of the combined sewage system between "Elsenbridge" and "Mühlendamm Sluice" are to be equipped with LURITEC installations (see maps in Figures 3 and 4). The necessary buffering volume for each discharge point varies between 200 m^3 and 11,500 m^3. With construction costs between EUR 1,200 and 3,000 per m^3, the project will require a total investment of EUR 60 Mill. for installation of a total volume of 42,000 m^3. Construction, including planning and authorisation, will take an estimated three years, with annual upkeep and maintenance costs of about EUR 75,000.

7_Financing of the extension of the pilot plant through a CSOP

The CSOP is a financing method that unites the cooperatives' closeness to citizens as small-scale investors with the flexibility of the limited corporation within the existing legal framework (see Figure 5). As a low threshold concept it provides credit financing while at the same time limiting individual liability of citizens to the sum of their contribution. Employing trust agreements between the citizens and a trust limited liability company (Trust-LLC) is sufficient to render shares easily transferable: In the event of a change of the citizen-shareholder the buyer or heir simply steps into the trust agreement in lieu of the former trustor. Unlike in the case of direct participation of consumers as shareholders of the CSOP holding limited liability company (CSOP-Holding LLC), changes of the citizen-shareholders need not be filed with the commercial registry; furthermore, the amount of the individual participation held and administered by the trustee can vary over time without necessitating any alterations of the share capital of the CSOP-Holding LLC.

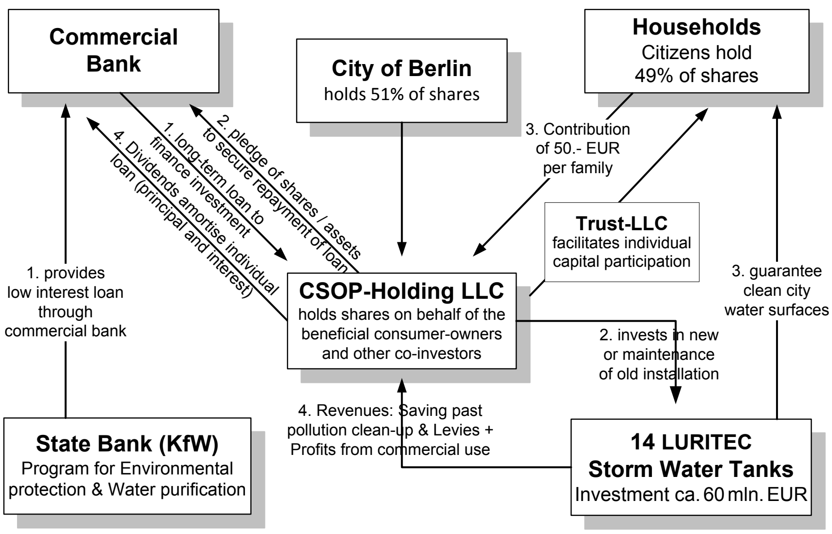


Figure 5. Financing a LURITEC System to maintain a clean Spree using the CSOP concept. Source: own illustration.

The indirect shared ownership using a separate intermediary entity, i.e. the Trust-LLC, which manages the shares held in trust for the citizen-beneficiaries and pools the voting rights executed by the trustee, implies a due "professionalization" of management: Participation in decision-making is channelled through the trustee while individual consumer-shareholders may execute control rights on a supervisory board or an advisory council. The CSOPs permanent administration and representation will ensue costs of EUR 120,000

[10] The model calculation assumes a conservative rent level, comparative rent levels can reach up to 17€/m²; see IHK Berlin (2015): Orientierungsrahmen Gewerbemieten, Berlin.

annually. Strategic investors like a municipality or an external investor can easily buy into the project acquiring shares in the CSOP-Holding LLC while being guaranteed corresponding voting rights (Lowitzsch and Goebel, 2013). This legal construction – also implemented as a standard model in real estate funds – renders the capital participation attractive not only for citizens but also for the city of Berlin and the Berlin Water Works.

In the Water-CSOP model proposed herewith (see Table 1) the city as majority shareholder contributes 51% of the investment sum (EUR 30.6 M.); the remaining 49% are raised by the CSOP though an initial, one-time contribution of the participating households (200,000 households each paying EUR 50 equals EUR 10 M.), equally nonrecurring environmental compensation fees (EUR 7 M., see Section 8c) and a bank loan (EUR 12.4 M.). Taking into consideration the majority shareholding of the city of Berlin as well as the CSOP's large equity share, the project can assume a low risk evaluation. For innovative investments with only limited risk the state-owned German Bank for Reconstruction (Kreditbank für Wiederaufbau – KfW) offers interest rates of 1.41% over a period of up to 10 years (KfW Group 2015).

Table 1. Basic data for the LURITEC Water-CSOP (Source: own calculations).

Total investment	60,000,000 €	Financing conditions	
Share of the city of Berlin	51% (30,600,000 €)	Bank loan	12,400,000 €
Share of the CSOP	49% (29,400,000 €)	Interest rate	1.41%
Total citizen's contribution	10,000,000 €	Annual Overheads	
Number of participants	200,000 households	Luritec maintenance	200,000 €
Contribution per household	50 €	CSOP overhead	120,000 €

8_The CSOP's sources of revenue and the amortization of the investment

As pointed out in section 5 turning the Water-CSOP profitable poses a certain challenge due to the specific nature of its service. In order to meet its liabilities the CSOP will combine a varied income mixture: a) a service fee equal to the amount of saved post-pollution costs (which include discharge penalties for polluting the river with untreated waste water as well as costs for measures to counteract the adverse effects on the aquatic ecosystem); b) Rental income from letting the newly created island properties; and c) nonrecurring environmental compensation measures legally imposed on other construction projects in the city. With a combination of these revenue sources (see Table 2) the redemption period for repaying the EUR 12.4 million debt is eight and half years (see Table 3; for an overview of income and expenses see Table 4).

Table 2_Potential revenues of the LURITEC Water-CSOP (Source: own calculations).

Basic data (annual revenues)	Assumptions rental income		
Communal savings discharge fees	501,505 €	River surface project area	540,000 m²
Communal savings "oxygen boat"	225,000 €	Thereof: New real estate	3%
Environmental compensation measures*	7,000,000 €	Thereof: commercial use	30%
Rental income	1,166,400 €	New area for rent	8,100 m²
* Total amount for implementing all installations		Min. rent per month[10]	12 €/m²

Loan: 12.4 Mill. € / Interest: 1.41%			
Year	Remaining Loan	Principal payments	Interest payments
1	11,000,695.01	1,399,304.99	173,600.00
2	9,581,799.74	1,418,895.26	154,009.73
3	8,143,039.95	1,438,759.80	134,145.20
4	6,684,137.51	1,458,902.43	114,002.56
5	5,204,810.45	1,479,327.07	93,577.93
6	3,704,772.80	1,500,037.65	72,867.35
7	2,183,734.63	1,521,038.17	51,866.82
8	641,401.92	1,542,332.71	30,572.28
9	0.00	641,401.92	8,979.63
Total		12,400,000.00	833,621.49

Table 3. Redemption period for the CSOP loan.

a) Saved post-pollution costs: LURITEC as a service provider to the city of Berlin / the Berlin Water Works

To determine an alternative revenue structure a change in perspective is necessary. Instead of charging the 'users' of a cleaned river, i.e., all citizens of Berlin, the Water-CSOP presents itself as a service provider to the city of Berlin or the Berlin Water Works respectively. Thus, it would bill those firstly responsible for preventing the adverse effects of sewage overflow on the river. Key to this approach is the fact that high costs for post-pollution clean up already occur to city and water works. The Berlin Water Works pay an annual EUR 1.5 mill. to compensate for the untreated discharge of sewerage water into the river (Berlin House of Representatives, 2015 c). These penalties are already a hidden part of the citizens' water bill. Additionally, an "oxygen boat" operating on the "Landwehrkanal" roughly costs an additional EUR 450,000 per year merely to prevent or at least reduce the periodically occurring pollution-caused mass-death of fish (Berlin House of Representatives, 2013)[11]. Partly, these costs can already be avoided by implementing the next LURITEC project phase as described above (covering the river from "Elsenbridge" to "Sluice Mühlendamm"). These savings can be channelled to the Water-CSOP during its amortization period (or permanently) as a service fee for its contribution towards maintaining a clean river and thus past pollution cost reduction. This would lay the foundation to refinance the CSOP's credit liabilities.

b) Commercial use of the artificial Spree islands

Implementing the extension of the LURITEC project creates artificial islands on the river with a combined surface of 22,000 m². This new real estate can at least partially be rented out for commercial purposes; we estimate 30% of the surface suitable. Rent payments make up the second mainstay to refinance the Water-CSOP. Along its course between East Harbour and "Sluice Mühlendamm", the river passes some of the city's most prestigious locations, while the waterfront offers lucrative potential for gastronomy, art and culture as well as for representative small-scale offices. The flexible, modular structure of the LURITEC system allows to flexibly position the islands as needed, largely independent of the actual discharge points. Connecting them underwater, the islands can thus be grouped to form larger surfaces in the most convenient and/or lucrative locations.

[11] On weekdays from May to September the "Oxygen Boat" rides along the Spree and neighbouring bodies of water enriching them with oxygen.

Naturally, utilizing the island surfaces poses challenges. The pilot plant in the East Harbour faced a strenuous bureaucratic quagmire about the usage of its surface, which eventually ended in a ban of any not technically necessary objects on the platform, including plants or any form of construction. Eventually, objections by the owners of a neighbouring riverside property turned out to be decisive side-lining actual legal issues.

The "Berliner Hafen- und Lagerhausgesellschaft mbh" (BEHALA) feared for the value of their properties, with the short-term sale of which they were charged. However, the upcoming project phase would phase less problems as the BEHALA by now has sold most of their riverside properties and thus will play only a minor role in upcoming negotiations. Furthermore, private owners and businesses should have little reason for similar opposition since in the long-run a successful project will most certainly lead to rising property values. Lastly, the Technical University's technical evaluation of the pilot phase will serve as a sound basis to argue the innocuousness of the LURITEC system.

Nonetheless, constructing on the river will remain subject to authorisation and it has to be taken into consideration that most likely neither the city nor the respective city districts will issue a carte blanche on the utilization of the islands. Therefore, the CSOP should present an overarching concept for its islands which besides commercial intentions should also include public use, e.g., recreational areas. As to live up to its own standards to allow for a broader civic participation, the CSOP has to strike the right balance between on the one hand economically viable but more exclusive and on the other a public but most likely unprofitable use of their properties.

c) The Spree islands as an environmental compensation measure for other construction projects

Compensation or replacement measures are an environmental policy tool to counteract environmental damages caused by progressing urbanisation; they have priority over monetary compensations which are subsidiary if compensation or replacement is not possible or unfeasible. For the sealing of surfaces during construction owners have to contribute to the renaturalization of other properties. Primarily, park and forest spaces are meant to be created or expanded, but also more broadly defined environmental projects can be financed this way.

The cost-by-cause principle remains applicable, meaning that a building's owner is obliged to implement the necessary compensation or replacement measures. Therefore, it is also on him to locate and choose applicable spaces (possibly his own) for compensation. According to the Federal Nature Preservation Act water ministration as such is not considered an environmental protection or landscape preservation measure. However, environmental protection measures falling under the act, e.g., Renaturalization including the greening of embankments and the growing of reed beds, can serve river purification (Berlin House of Representatives, 2015 b). Against this background the aim is to place the LURITEC installations of the Berlin Water-CSOP as a possible target for compensation or replacement measures in order to generate an additional source of revenue.

Expenses		Earnings	
Principal payments:	12,400,000.00 €	Rental income:	9,929,144.98 €
Interest payments:	833,621.49 €	Saved post-pollution costs	
Maintenance costs:	1,800,000.00 €	/ oxygen boat:	1,915,344.32 €
CSOP overheads:	1,090,000.00 €	/ discharge fees:	4,269,132.19 €
Total:	16,113,621.49 €	Total:	16,113,621.49 €

Table 4. Total Earnings and Expenses over a 10 year period.

d) Citizen Donations

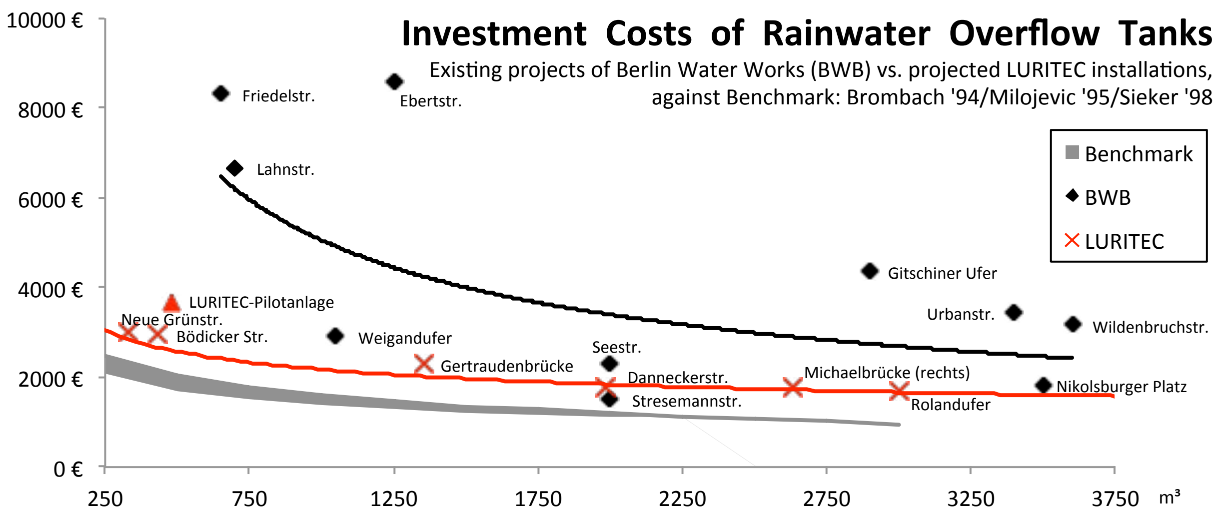
As earlier mentioned, citizens already share the cost of pollution clean-up through charges to their water bill, although to date these costs have not been separately itemized; consequently, consumers remain unaware of them. This poses the question of how much of this cost the citizens of Berlin would be willing to voluntarily contribute to underwrite a pollution-free environment. If they were willing, the Water-CSOP's financing costs would be reduced and it would be easier for low-income households to participate.

This last point is important because the lack of income becomes an issue when broad citizen participation is desired. While the initial equity contribution remains in the low range of EUR 50 to 100, given the high percentage of poor inhabitants in Berlin, compared to other German cities, a significant number of households may consider this contribution too costly. A donation fund should be considered to facilitate the participation of low-income households. Studies on citizen appreciation of environmental amenities (e.g., a clean river) suggest that there is general willingness to pay for restoring or maintaining natural surroundings (Kölbel, 2010 / Liesenfeld et al., 2012). This willingness, however, varies greatly from region to region. Donations should be considered only as a complimentary measure to fill potential financing gaps.

9_Comparison of Conventional Measures with the LURITEC System

Construction costs of concrete underground rainwater tanks sink as volume rises. The literature assumes costs from up to EUR 2,500 to slightly under EUR 1,000 per cubic meter (Brombach 1994 / Milojevic 1995 / Sieker 1998). A tank of 250 m³ for example would cost twice as much per cubic meter as a tank of 2,000 m³; the most notable cost savings occur in this range, and apply to both

Figure 6. Comparison of Costs for Rainwater Overflow Tanks in Berlin. Source: Calculations against benchmark by P. Slevec using data from Berlin Water Works and LURI.watersystems. GmbH.



the concrete tanks contemplated by the Berlin Water Works and the glass fibre tubes of the LURITEC system although the cost level is generally higher (see cost comparison in Figure 6).

In general construction costs in Berlin are high because of urban density in particular, as utility lines may have to be rerouted. LURITRC plants being built underwater do not affect the existing infrastructure. This feature alone makes the LURITEC system a cost-efficient alternative which is particularly obvious for basins of up to 3,000 m^3 as shown in Figure 6.

10_Potential Partners and Stakeholders

To be successfully implemented, the Water-CSOP will require close cooperation with the City of Berlin, the districts bordering on the river, the water- and shipping office and, most importantly, the Berlin Water Works itself. Even with the city's major financial contribution, districts have a right to veto objectionable changes to their neighbourhoods. The Berlin Water-CSOP must also involve its citizen participants in ways beyond financial incentives. Because the Water-CSOP is more of a civic than economic project, it is important to involve civic organizations, especially those active in water uses and public participation. Dialogue with civil society will allow potential objections and problems to be detected and addressed at an early stage.

11_Optional Expansion of the Concept Incorporating a Communal Policy to Balance Gentrification

The Berlin Water-CSOP can also ease the gentrification that an improvement in water quality will most likely bring about. As soon as previously polluted urban rivers, ponds or lakes are cleaned up and made attractive for a wide range of recreational activities, properties on or near waterways will become popular. Thus however the Senate administration decides to improve water quality – implementing the obligatory EU standards and facilitating bathing in the inner city area – the value of waterside properties will significantly rise. Rental increases may lead to social friction and conflict with established tenants – a consequence that the Senate probably neither intends nor wishes.

The on-going debate in Berlin about freezing rental levels shows that communal policy intervention is far easier to demand than to implement. Conflict over maintaining a clean Spree may arise between the *Berlin citizenry* – the ones who eventually pay for the project, not only directly through their investments but indirectly through taxes and water bill charges, and the small minority of property owners who would economically benefit from increasing rents resulting from the project's success. This is a classic example of the free-rider effect which compromises the primary objective of providing public access to all citizens, especially those who are unable to afford recreational facilities outside of Berlin. As it presently stands, an effort to improve urban living quality for the public in general may mainly benefit a small and already well-capitalized segment of the population while unintentionally shutting out a much larger population of citizens who are less well-off.

The CSOP concept, based on wide citizen participation and financial participation, may help to prevent this development. To compensate for this accidental free-rider effect, property owners might pay a small percentage of the appreciation triggered by the environmental improvement to the CSOP – perhaps in the range of 3 to 5 per cent – as a levy. Once the bank loan is repaid the CSOP would distribute payments from this levy to its participants who financially committed to realize the project as dividends. Obviously – to defuse accusations of introducing a special tax – this would be conditional on an actual appreciation of the real estate in the area. Such levy may be realized either on a voluntary basis or on as a compulsory duty. As a result CSOP participants would gain financial compensation for their commitment that could equally help to balance the expected rises in rents; at the same time the direct profiteers of the measures would bear their fair share of the expenses. Thus, free riding of non-participating citizens as well as of profiting property owners could be avoided.

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Urban Infrastructure for Post-Carbon Cities

THE 2012 LONDON GAMES: CAN OLYMPIC LEGACIES BE SUSTAINABLE?

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Abstract

Mega-events, from the Olympics to the World Cups, are often regarded as catalysts for the overall redevelopment of a city. Mega-events have driven the urban transformation of cities like Barcelona or Beijing, but while the prospect of economic growth is the leading force for hosting them, the legacies that follow their staging, especially regarding sustainable development, are difficult to design and quantify. The research draws an investigation into the impact of mega sports events on the built environment, focusing on the analysis of the 2012 London Olympic Games. The aim of this study is to assess of the real legacies of the 2012 Olympics in London in terms of sustainable urbanism, with particular regard to the public open spaces created (Queen Elizabeth Olympic Park and the Olympic Village). The case of London was selected, among other Olympic cities, because the British capital was the first Olympic city with a comprehensive legacy plan and a sustainability strategy already in execution before the hosting of the Games. Moreover, the case of London offers a wide variety of legacies that can be analysed. Future research will focus on the development of a comprehensive framework for appraising legacies of mega sports events, focusing on their long-term self-sustained impacts, which means an analysis of the economic, social, environmental, but cultural and governance-related legacies.

1_Introduction

It is acknowledged that in the last three decades the relationship between mega events and strategic interventions of urban planning have gradually assumed more and more importance for the sustainable development of cities (among others: Liao and Pitts, 2006; Smith, 2012). In a sense, the event adds some elements of advantage and disadvantage to the urban planning processes. On one hand, thanks to the availability of special funding and deadlines usually unavoidable, the implementation of interventions enjoys a sort of guarantee on the result; but at the same time, the event needs to be strongly planned and managed, if the aim is to give the city new sustainable areas in terms of quality of services and functions. It is also important to clarify that a mega-event itself is not a sufficient element of effective and sustainable urban renewal. Pursuing the redevelopment of the city only through extraordinary events can be a risky approach, as the speed and acceleration given by mega-events are not necessarily synonymous with good and sustainable planning (Essex S. and Chalkley B., 1998; Preuss, 2007). In any case, the relationship between sustainable urban development and major events is becoming stronger and stronger, and it may create opportunities for urban transformation, construction of sports facilities and infrastructure, conversion of open spaces and places in economic and social decline. Major events cannot obviously be considered all at the same level, but some common elements are found. Among these, firstly, the problematic relationship with land use planning and environmental issues, and the legacies concerning urban transformation, of tangible and intangible infrastructure, and permanent cultural changes (Musco, 2012).

Within this context, the paper draws an investigation into the impact of mega sports events on the built environment, focusing specifically on a single case study: the analysis of the 2012 London Olympic Games. The aim of this study is the assessment of the real legacies of the 2012 Olympics in London in terms of sustainable urbanism, with particular regard to the public open spaces created (the Queen Elizabeth Olympic Park, and the Olympic Village). The case of London was selected, among other Olympic cities, because the British capital was the first Olympic city with a comprehensive legacy plan already in execution before the hosting of the Games. More, the case of London offers a wide variety of legacies that can be analysed. A broad amount of literature is available on the 2012 Olympics; however, the majority of it discusses legacies before the staging of the Games (before 2012), while very few research works attempt to carry out an evaluation after the conclusion of the Games. In addition, despite the promises, usually legacies tend to be negative, especially when considering the post-event usage of the major events sites and sports venues. Usually, sports facilities become white elephants, and event sites turn into non-places or abandoned islands within cities. However, the case of London offers useful insights that revert this negative trend, especially when considering the legacy plan and its accordance with the London master plan, and the integration of East London where the Games took place with the rest of the city that resulted from the stage of the Olympics.
The paper is structured as following: the next section explains the research design and the methods adopted for the data collection and analysis, with the most relevant methods consisting of interviews with experts and site visits. Then, the paper briefly presents an analysis of the main data collected and results, that can be summarized into four main topics: first, a strong political leadership and vision is needed to achieve positive legacies; secondly, it is essential to plan ahead instead of retrofit, and a legacy plan already in execution before the stage of the event it is a must. The legacy plan needs also to consider local needs and specificity. Third, events' expenditures are one of the main issues when dealing with mega-events, as the final costs for the planning, management, and construction are always at least the double of what estimated. Finally, the main stadium always represents the most sophisticated facility to be planned, and even in the best scenarios, its management leads to inefficiencies and high expenditures for its reconversion, management, and maintenance.

2_Methodology

The methodology adopted to investigate the case of London is multi-layered and composed of a mix of different methods. The case of London, and more specifically the Queen Elisabeth Olympic Park, which constitutes the main legacy after the stage of the 2012 Olympic games, was analysed according to a threefold data collection. Firstly, an analysis of the official documentation, and, in particular, the bid book, the post-event report, and the London Plan, which is the city master plan, was conducted. This process allowed identifying the sustainable legacy goals and real achievements. Then, empirical methodologies, and, in particular: behavioural studies, walking through analysis and direct observations were performed. In particular, a set of ten observation points were selected among the main areas of the park, and a series of site visits were conducted in 2015 (Figure 1). The visits were performed on different days of the week and different time, to obtain more reliable data, and each session lasted around three hours. These techniques allowed collecting data with particular reference to people visiting the park and more generally the area, with measurements on flows, activities, demographics, ethnicity, and the built environment, with reference to safety and security, comfort, accessibility, attractiveness and pleasantness. Finally, a set of face-to-face semi-structured interviews with experts was conducted. Several experts involved in the planning of the event legacies were chosen within the following fields: academia, local politicians and people belonging to the local Organising Committees, professionals and practitioners. The list of questions covered three main areas: a personal definition of legacy, with particular reference to time and beneficiaries; personal experience on the 2012 Games, with the identification of best and worst practices, principal pitfalls and achievements; and a personal opinion on how different hosting cities (i.e. developing vs. developed cities) and different sport events (i.e. Olympics vs. World Cup) can achieve/promote beneficial long-lasting and sustained legacies.

Figure 1. The map of the London Olympic Park and the ten observation points selected (Source: Author).

3_Data Collection, Analysis, and Results

3.1_An overview on the 2012 Olympics

In 2005, London was awarded the 2012 Summer Olympics, becoming the first city ever to host three editions of the Games. The 2012 Olympics were planned to use a mix of new venues, and existing or temporary facilities, some of them in well-known locations such as Horse Guards Parade or Hyde Park. To avoid some of the problems that plagued previous events and facilities in the city, the intention was to prevent the proliferation of white elephants after the Games (Queen Elisabeth Olympic Park, 2015). Some of the new facilities were planned to be reused in their original form while others were designed to be reduced in size or dismantled. The main goal was to contribute to the regeneration of Stratford in East London, the site of the Olympic Park, and of the surrounding areas. Stratford is located in the borough of Newham, which is situated 8 km east of the centre of London, and is north of the River Thames. According to 2010 estimates (Greater London Authority, 2004), Newham had one of the highest ethnic minority populations of all the districts in the country, and its regeneration would have helped in the process of convergence identified by the local master plan (the London plan), providing East London with the same opportunities of the wealthy West London. However, the selection of Stratford led to the compulsory purchase of some businesses that caused some controversy, with some of the company owners claiming that the compensation offered was inadequate. The acquired buildings were destroyed to make space for Olympic facilities and infrastructure improvements, giving birth to the new Queen Elisabeth Olympic Park.

3.2_Interviews with experts

Ten interviews with experts involved in the planning of the sustainable legacies of the 2012 Games were performed in London between September and November 2015. The interviewees included academics, local politicians, architects and planners, and local governance and organising committees' members. The interviews showed a general satisfaction regarding the positive legacies achieved after the stage of the Games. The majority of the interviewees agreed that the positive outcomes are a direct consequence of the mix of strong leadership, good time management, and design of a legacy plan that take into account the real local needs and specificity.

One of the strengths was the harmony between the local master plan and the legacy plan designed for the Games. In fact, the 2004 London Plan identified Stratford and East London as an opportunity area of intervention in the city. The redevelopment of these neighbourhoods was already planned, and the Olympics accelerated the process, with a catalyst effect that made these plans quicker to be achieved. More, three master plans were designed for the area: one for the stage of the Games, one for the transition period, and one for the final legacy mode. This strategy allowed identifying the needs for each phase, and to design the right mix of permanent and temporary facilities, and other infrastructure needed.

Finally, a successful time management is another important factor to consider: all the venues were ready well before the Games. This allowed developing the legacy plan with the right pace and focusing on the post-event usage of space and the venues.

3.3_Site visits

With the aim of mapping the built and natural environment, but also, the flows of people in the park, a series of site visits were performed along 2015. A set of ten observation points were selected among the main areas of the park (Figure 1), with measurements on flows of people that utilized the park, their activities, demographics, ethnicity, but also with an assessment of the built environment, with reference to safety and security, comfort, accessibility,

attractiveness and pleasantness. A checklist and a plan of each point selected were utilized for the mapping.
The overall appraisal showed that the park is easily accessible and integrated into the city centre, being one of the most connected places in London, thanks to the presence of two metro lines, several over ground trains and DHL, a bus station, and a high-speed railway station. More, the area offers a variety of functions and uses. First, the Olympic Village nearby was reconverted to host almost 3,000 apartments, with a new school and health centre. More, Newham is home to Westfield Stratford City, which is considered the largest shopping mall in the European continent, and provides commercial activities and shops. Finally, universities as UCL (University College of London) and Loughborough, and other cultural institutions are planning to open a new branch there.
Regarding public transportation, Stratford, the main access point to the area, was already well connected before the Games, but it is now reached by two metro lines, some over ground and DLR (Dockland light railway) connections, a bus station, and a high speed railway station. This improvement in public transportation also helped in integrating the park and the surrounding within London.
More specifically, coming to the evaluation of the park, the assessment showed that the sports facilities, with the exclusion of the Olympic stadium (Figure 2), are partially or fully utilized by Londoners. This was made possible thanks to a careful planning of the venues. All the facilities that were considered non-necessary for the local community were dismantled after the Games, and only four major infrastructures were left (an aquatic centre, a multipurpose arena, a tennis and hockey complex, and the stadium). The park offers a wide area of green spaces and is fully utilized by local residents, especially during the summer and the warmer periods of the year, when residents go for a walk, a picnic, or to attend one of the many events that take place in the park. Young families and children, along with sportsmen, are the main utilizers of the space. The area is overall well maintained and secure; however, two main issues threat the success of the sustainable legacies of the space: the maintenance costs, and the management of the stadium. The park is a vast space of almost 230 hectares, and in the long run, the high expenditures for its maintenance will force the city of London either to find external or private sources of funding, with a privatization of the space, or to close part of the park, to reduce the expenditures. Finally, at the time of writing, the stadium is the only infrastructure that is still closed and under transformation. The 80,000-seat Olympic Stadium was firstly planned to be reduced to a 25,000-seat multi-purpose facility to be utilized for athletics events, with the aim of becoming the most important hub in the East London for sports activities. However, later on, its destination changed, and it is now undergoing transformation to be converted into a 54,000-seater stadium, for use by West Ham United FC, alongside athletics in the summer months and entertainment. This change caused delays in the re-opening, and an increase of costs, because it was necessary to make substantial changes to the initial project, and make the athletics track retractable to allow the dual use of the stadium: as venues hosting football matches and athletics events.

Figure 2. The Olympic Stadium (Source: Author).

4_Conclusions

Cities compete to bid and host mega-events, but, according to the literature, results in term of sustained/sustainable long-term legacies are normally negative. The overall aim of this research was to understand how to make a proper use of mega sports events, by promoting, implementing, and delivering long-term sustainable legacies. More specifically, the primary goal was the assessment of the real legacies of the 2012 Olympics in London, three years after the hosting of the event, with particular regards to the public open spaces created. Within this context, this research attempted at appraising the Queen Elisabeth Olympic Park in East London, measuring its sustainable outcomes. The analysis showed that the city of London, although with some limitations, succeeded in creating an open space, the Queen Elisabeth Park, which is truly integrated into the city, easily accessible, and utilized by a broad range of residents (Figure 3 and 4). This was made possible thanks to the integration of the local master plan and the legacy plan implemented for the event. An early start of legacy planning and a focus not only on the physical, but also on the social and intangible impacts are another two of the successful strategies of these Games.

The main limitations of the space regard the overall costs that widely exceed the proposed budget in the bid book, including the expenditure relating the maintenance of the park and surrounding areas. A second issue involves the management of the Olympic stadium, the only facility still closed after the full reopening of the park, due to a change in its final use.

Future work will attempt at defining a framework for appraising and evaluating the outcomes (legacies) of mega sports events, focusing on their impacts concerning sustainability, which means an analysis of the economic, social, environmental impacts, but also an investigation of the cultural and governance-related repercussions.

Figure 3. The velodrome within the Olympic Park (Source: Author).

Figure 4. An overview of the park (Source: Author).

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ISTANBUL METRO: A POSSIBLE EXAMPLE OF ENERGY GEOSTRUCTURE

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Abstract

The exploitation of thermal inertia of the ground by incorporating heat exchanger pipes into tunnel linings has been recently proposed. This paper investigates a possible application for a new metro line currently under design. The Dudullu-Bostanci line, planned to be excavated in the Turkish city of Istanbul is considered. The heat exchange potential for the tunnel is evaluated, together with the environmental and economic impacts.

1_Introduction

Today, more than 50 percent of the world's 7 billion people live in cities, and, by 2050, this will rise to 70 percent. Roughly, 75 percent of global world economic activity grows within cities, and, as the urban population grows, so will the urban share of global GDP and investments (McKinsey, 2011). Urbanization will increases over the next several decades, with the dynamism of cities representing a major sustainable development opportunity. A city's ecological footprint contributes significantly to climate change, as they consume two-thirds of the world's energy and produce approximately 70% of the greenhouse gas emissions. At the same time, cities are ideal focal points for strategies on reducing greenhouse gas emissions.
Urbanization has created a pressing need for infrastructure investment. Cities must have functioning traffic systems, intelligent logistics, efficient energy supplies, and environmentally compatible infrastructures.
Managing growing cities with decreasing budgets and increasing complexity, along with the expectation of a higher quality of life, places heavy demands on both infrastructure and environment. The megatrends urbanization, demographic and climate change will shape the future. Mobility is the key for cost-effective and environmentally friendly urban development. By relying on renewable energy, electro-mobility will significantly reduce environmental impact. This contribution to sustainability is magnified by the parallel use of the underground space, as it is for most of the urban metro lines. Putting infrastructures underground gives an unparalleled contribution to sustainability: saving land, reducing travel-time and unnecessary visual and noise intrusion.
Managing growing cities and their supply of resources is a formidable task that places heavy demands on infrastructure and the environment. The scientific community is focusing on finding solutions that will support economic growth while reducing pollution and waste. Well-designed sustainability measures deliver multiple benefits. The effectiveness of a metro line reduces traffic and greenhouse gas emissions. Reducing congestion improves city dwellers quality of life and cuts the cost of doing business by making delivery times more consistent and reliable.
Starting from these considerations, this paper fixes an innovative solution for adding to the intrinsic benefits of an underground metro line the use of thermal energy from renewable resources. The long metro tunnels (using heat exchangers integrated in the tunnel lining) became a remarkable source of energy exploiting the geothermal resources by active heat exchange with the ground.

Nonetheless, it is relevant to focus, as the exploitation of low enthalpy geothermal wells in urban areas must be planned with wisdom, considering the whole aspects of sustainability. The increasing implementation in several areas of the world of the open-loop groundwater heat pumps technology which discharge into the aquifer for cooling and heating buildings, could potentially cause, even in the short term, a significant environmental impact associated with thermal interference with groundwater, particularly in the shallow aquifers (Lo Russo et al., 2014, Taddia et al., 2013). Moreover a future underground space dense of deep vertical wells could impair the use of the underground spaces, paradoxically reducing the overall sustainability budget. The solution here discussed balances the reciprocal benefits of the three contributors; the metro line itself, the use of the underground (considering that the metro line itself consumes underground spaces, nevertheless less and with benefits for a larger community) the new frontiers of the geothermal exploitation.
Real applications of energy tunnels are very limited. The Jenbach tunnel in Austria (Franzius et al, 2011; Frodl et al, 2010) has been equipped with heat exchangers in the segmental lining to provide heat for a municipal building. An experimental site was also tested during the construction of the Katzenberg railway tunnel in Germany (Franzius & Pralle, 2011). Other applications took place in the Lainzer tunnel in Austria, where pipes were integrated into the construction of a sprayed concrete lined tunnel (Markiewicz & Adam, 2009), and a geothermal test section was set up at in the Stuttgart-Fasanenhof Tunnel (Scneider & Moormann, 2010).
This work is based on the studies on energy geo-structures performed at the Politecnico di Torino which considered tunnel energy segments for the lining of the Turin metro tunnels (Barla & Perino 2014a, 2014b, Barla et al. 2016, Di Donna & Barla 2016). The application to the Istanbul metro case study is supported by Geodata S.p.A., designer of the metro line.

2_Description of the case study

Istanbul, one of the world's fastest-growing metropolitan area, has advertised a number of incredibly ambitious infrastructure projects to be realized by 2023, the 100th anniversary of the founding of the modern Turkish republic. Istanbul is a mega city that stretches over two continents, separated by the Bosphorus Strait. Today more than 13 million people are living in Istanbul – 18% of Turkey's population. Mobility is the biggest problem facing the city, with the Bosporus Strait dividing the Anatolian from the European side. To address the increasing and urgent demand for improved connectivity, a total of more than 130 km of public transportation routes are under construction, including both metro and tramway systems, all representing part of the very ambitious development program of the Turkish Government to bring into service more than 500 km in a decade.
The Dudullu-Bostanci (DB) Line is part of this huge, expanding, network, in the Anatolian side (Kocaeli Peninsula) of Istanbul. It runs, completely underground, from south to north with a length of 14 km, 13 new stations, and a train depot. It crosses the Kadıköy–Kartal Metro Line, the trans-European railway line and the Üsküdar-Çekmeköy Metro Line.

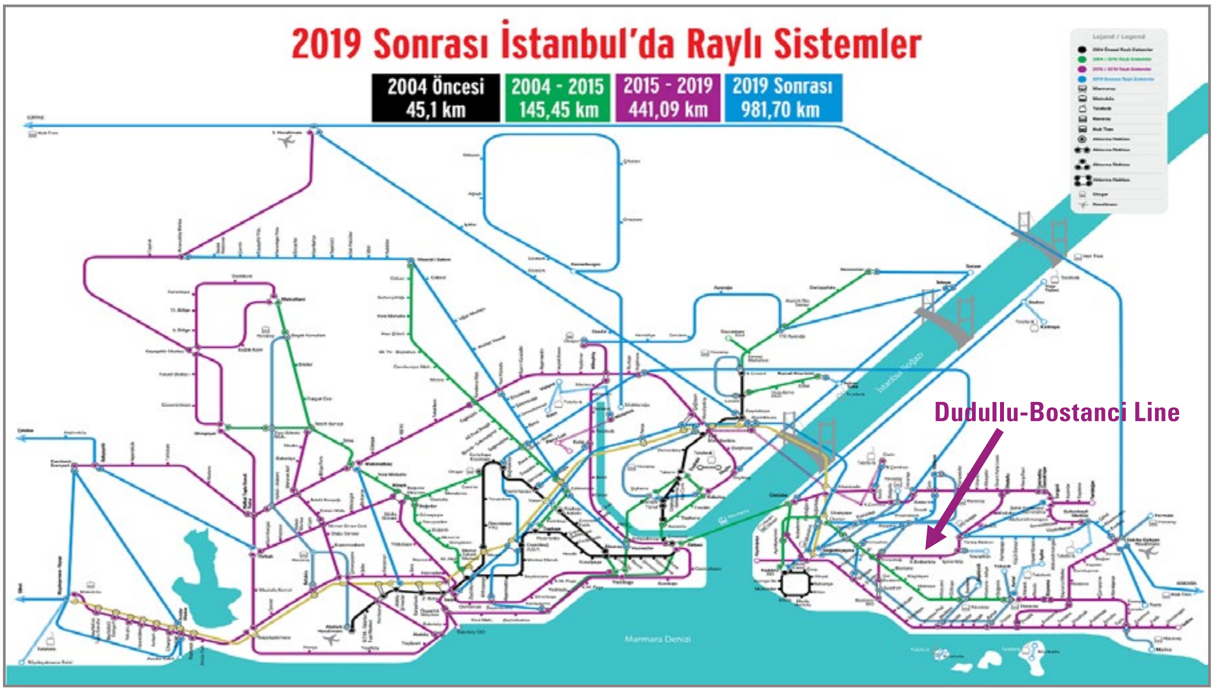


Figure 1. The development plan of the metro network in Istanbul, with the Dudullu-Bostanci Line.

The underground line starts from the Bostanci Station as a twin tube tunnel (both of which driven with Tunnel Boring Machines). After about 13 km, under-passing the densely urbanised Anatolian Istanbul, from the Yukari Dudullu station the line will be mined (with conventional excavation) for 1.5 km as a single tube tunnel. A fully automated metro system will be implemented (GoA4) with driverless trains, CBTC, and platform screen doors at stations. The line is expected to be completed by 2019. It is connected with the Bosphorus ferry (at Bostanci Harbour), the Marmaray railway, the Kadıköy-Kartal line and the Üsküdar-Çekmeköy line, under construction.

The ground level above the tunnel alignment varies from about 4 m (Bostanci Station) to about 150 m above sea level, near Yukari Dudullu station. The hilly landscape is shaped by the presence of a, relative hard, Palaeozoic bedrock. This bedrock is covered by alluvial materials, slope deposits (eluvio-colluvium, deposits related to landslides) and anthropic filling along the stream valleys. A variable thickness of residual soil materials, somewhere deep, related with alteration/weathering processes, covers and/or penetrates the underlying bedrock units. Transitional (continental – marine) sediments border the shoreline. At a first level the conceptual hydrogeological model includes three main complexes: a first layer, discontinuous, of soils (porous), then a very variable (laterally discontinuous) thickness of altered/weathered rock masses (dual porosity, somewhere primary, somewhere along factures), then the hard rock masses (discrete fracturing, secondary porosity).

3_Determination of geothermal potential

In order to assess the potential of using the tunnel lining as heat exchanger with the subsoil, it is important to determine the heating potential of the different geological formation interested by the excavation.

The heating potential can be defined as the specific capacity to transfer heat and is measured in W/m^2, it is different for heating or cooling purposes, and depends essentially on the temperature of the subsoil, on the velocity and direction of the groundwater flow and on the thermal conductivity of the soil/rock. It also varies on the basis of the velocity of the heat transfer fluid in the pipes, on the spacing of the pipes, on the temperature of inlet fluid and the total length of the circuit.

The heating potential can be assessed by heat transfer and fluid flow finite element analyses. Examples are given by Barla et al. (2016) and Di Donna & Barla (2016). The output of the numerical analyses is the difference between the inlet and the outlet temperature of the heat transfer fluid from which one can compute the heat exchanged with the ground.

Based on extensive research performed at Politecnico di Torino, Di Donna & Barla (2016) also suggested a simplified and preliminary approach to assess the heating potential for specific site conditions based on the use of the design charts shown in Figure 4 which are affected by a number of simplifying assumptions:

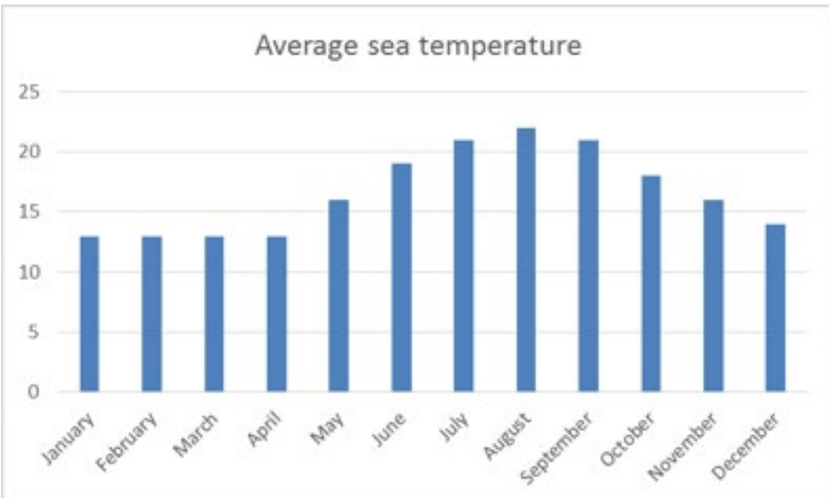
- influence of neighbouring rings neglected;
- underground flow rate perpendicular to the tunnel axis;
- pipes located at 10 cm from the extrados and with a distance of 30 cm;
- inlet water temperature of 4°C in winter and 28 °C in summer;
- inlet water velocity equal to 0.4 m/s.

For the case study of interest in this paper, this latter approach was used to assess the geothermal potential of the project. For this purpose, the metro line was divided in sections homogenous from the geological and hydrogeological point of view, and for each section the corresponding parameters (temperature, groundwater flow rate and thermal conductivity) were assessed and, consequently, the heating potential.

3.1_Determination of underground temperature

The temperature of the subsoil was not investigated during the survey campaign related to the preliminary design process. The monthly air temperature of Istanbul is clearly not representative for the subsoil. As a first approximation, the ground temperature is assumed to be equal to that of the sea water (Figure 2), based on the higher thermal inertia of water with respect to air and on the proximity of the track to the sea.

Figure 2. Average sea temperature in Istanbul.



Average temperatures for cooling and heating periods were considered based on Durmayaz A. (2000). The assumed temperatures are given in Table 1. It is clear that these values are a simplified assumption that should be assessed by proper site measurements in the case thermal activation of the tunnel lining will be effectively considered in the future.

Table 1. Average subsoil temperature for the heating and cooling periods.

Heating [°C]	Cooling [°C]
14.29	19.80

3.2_Determination of thermal conductivity

Thermal conductivity was determined thanks to correlation with the Uniaxial Compressive Strength, (UCS) of the rock, according to Yasar (2008). Values of thermal conductivity are given in Figure 3 as a function of chainage. Only the sections with higher thermal conductivity are considered in the following for heat exchange application (i.e. PK from 8.8 to 9.6 km).

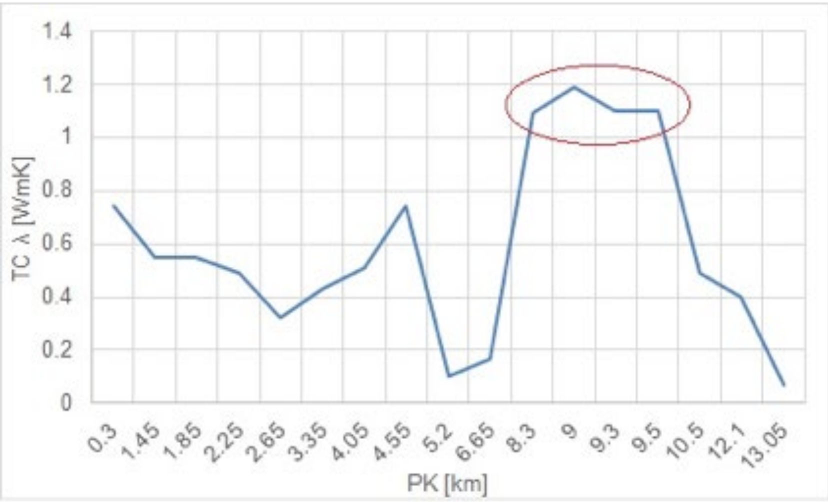


Figure 3. Thermal conductivity versus chainage.

3.3_Determination of groundwater flow rate

The groundwater flow rate strongly influences the geothermal potential of the tunnel, contributing to the heat exchange by convection. It depends on the permeability of the medium and the hydraulic gradient applied. It is possible to estimate the flow rate velocity using the Darcy's law. This was done for each section of the tunnel.

Lugeon tests were conducted to determine the hydraulic conductivity of the rock mass formations while Lefranc tests were performed in soils. Average values were considered. The hydraulic gradient was estimated thanks to the hydrogeological map (Istanbul Metropolitan Municipality 2014).

3.4_Estimation of the heat exchange potential

Di Donna & Barla (2016) design charts shown in Figure 4 were directly used for the evaluation of the heating potential for the most promising section in the rock mass formation (Section A), where higher conductivity is present, and in the soil (Section B), where the permeability is higher. Detailed data are given in Table 2.

The geothermal potential resulted to be higher for Section B (Tab. 3), both in heating and cooling mode, mainly because of the flow rate velocity that increases heat transport by convection. These values compare satisfactorily well to the other existing data shown in Figure 4. The high difference with the Torino case study is mainly related to the very favourable conditions in this city (1.5 m/day of ground water flow and 14°C of ground temperature year round).

Table 2. Heating and cooling potential for most promising sections along the tunnel alignment.

Sect.	Formation	PK [km]	Geol. formation	Hydraulic conductivity k [m/s]	Flow rate v [m/d]	Thermal conductivity λ [W/mK]	Groundwater temperature [°C]	
							Heating	Cooling
A	Rock	8.8 - 9.2	Kurtköy	1.00E-06	~ 0	1.19	14.29	19.80
B	Soil	11.4 - 12.8	Sultanbeyli	2.60E-05	0.225	0.38	14.29	19.80

Table 3. Heating potential for Sections A and B.

Section	Heat extraction (W/m^2)	Heat injection (W/m^2)
A	10	15
B	20	20

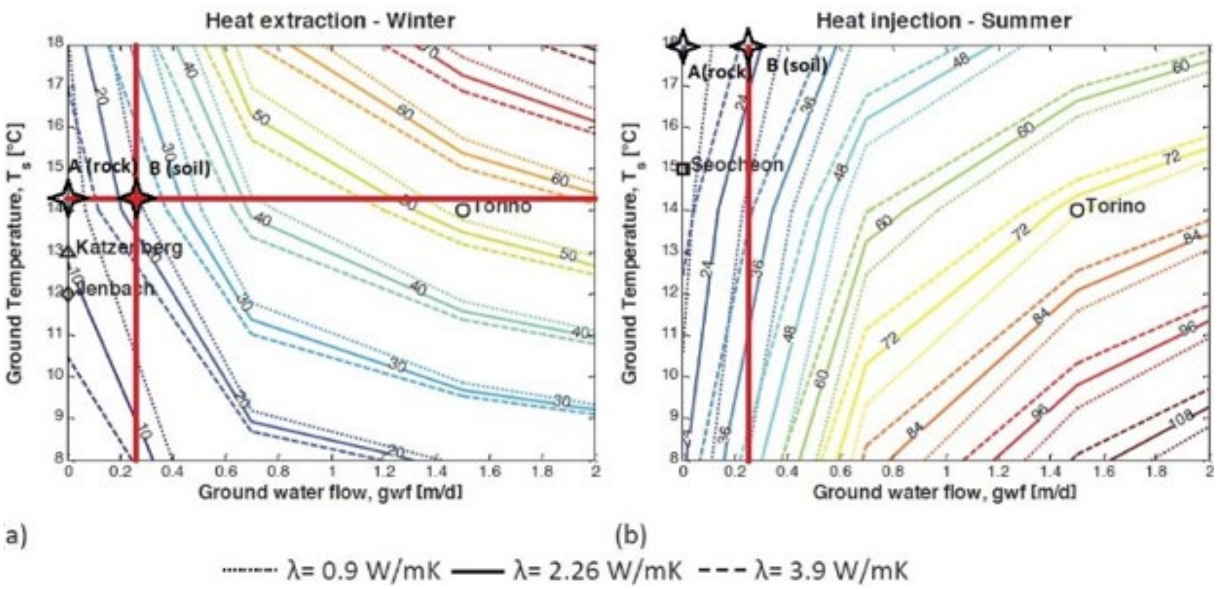


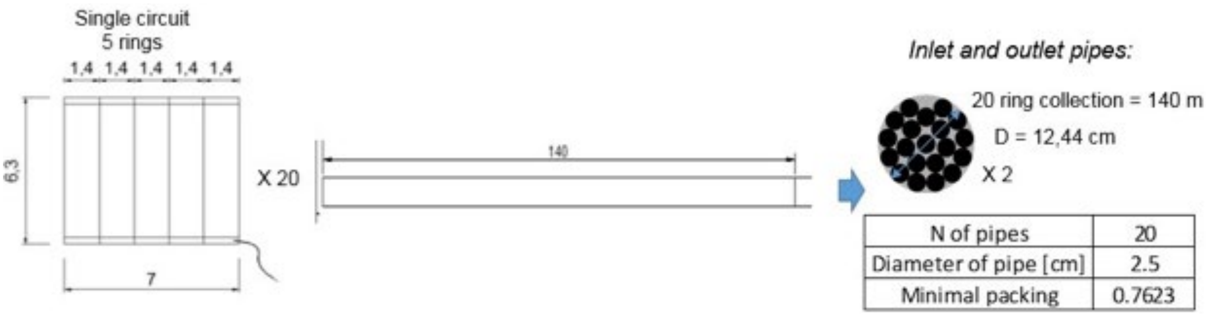
Figure 4. Evaluation of heat extraction (a) and injection potential (b) for Section A and B, according to Di Donna & Barla (2016).

4_Technological aspects for tunnel lining activation

Technological aspects related to the activation of the tunnel segmental lining with heat exchangers are similar to those proposed for the Jenbach tunnel (Frodl et al. 2010, Franzius and Pralle 2011) and for Turin metro tunnel (Barla & Perino 2014, Barla et al. 2016). The heat exchanger fluid flows into pipes embedded in the concrete of the lining segments, which are installed by the Tunnel Boring Machine. Joining of the circuit is accomplished after installation.

The absorber pipes consist of cross-linked high resistance polyethylene (PE-X). The external diameter of the pipe is 25 mm and the average spacing in the lining is between 25 to 30 cm. A good compromise between efficiency and practical application was found to be obtained by joining together 5 rings in series, to form a single circuit, and then connect each circuit in parallel with the others (Barla et al. 2015).

The tunnel external diameter for Istanbul metro is 6.3 m and the longitudinal thickness of the ring is 1.4 m. Therefore each circuit of 5 rings is 7 m long. Based on these assumptions, a group of 20 circuits, covering a total length of 140 m, will need 20 inlet and 20 outlet pipes, resulting in two equivalent tubes of 12.5 cm of diameter (Fig. 5).



N of pipes	20
Diameter of pipe [cm]	2.5
Minimal packing	0.7623

Figure 5. Geometry of the heat exchanger system.

Once the geometry of the problem is defined, it is possible to compute the total power generated by the system, based on the geothermal potential of the ground (20 W/m² both for heating and cooling) for the section with higher potential. The result is given in Table 4 with reference to a 140 m (2 tubes) and a 280 m (4 tubes) length.

Considering an operating time of 6000 h per year (i.e. 3500 h for heating and 2500 h for cooling), the total annual energy produced by the system can also be evaluated as shown in Table 5.

Table 4. Heating power for Section B.

Heating potential [W/m²]					Heating power [kW]	
Winter	Summer	Number of equivalent tube	Tunnel diameter [m]	Length of installation [m]	Winter	Summer
20	20	2	6.3	140	55.4	55.4
20	20	4		280	110.8	110.8

Table 5. Annual energy produced for Section B.

Length of installation [m]	Heating power [kW]		Hours of working [h]		Annual energy produced [MWh]		Annual energy produced [GJ]	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
140	55.4	55.4	3500	2500	194	138.5	698.4	498.6
280	110.8	110.8			387.9	277.1	1396.44	997.56

This application shows quite an important amount of thermal energy available in the subsoil. It is important to underline that these energy values are based on the hypothesis of maximum efficiency of the system, which can be affected by several issues. However, despite the preliminary status of this study, the results are in line with existing in situ experimental measurements that show heating potential in the range 10 to 20 W/m^2 (Franzius et al, 2011; Schneider et al, 2012).

5_Environmental and economic aspects

The application of heat exchangers in the tunnel lining is designed with the main purpose to exploit renewable energy for heating and cooling of buildings. Environmental impact as well as economic aspects needs to be evaluated within a cost/benefit analysis of such a system. This is done in the following, in a very preliminary form, by considering 1 km of tunnel activation for heating and cooling purposes.
The information needed are:

- the Coefficient Of Performance (COP) and Energy Efficiency Ratio (EER) of the heat pump, both assumed to be equal to 5 (model Hidros WHA/RV/SW6090: COP=5.5, EER=5.2);
- the annual electricity used by the Ground Source Heat Pump (GSHP) to heat and cool the water for the end user which can be determined dividing the annual energy produced by the heat exchanger system for the COP and EER of the heat pump;
- the emission for the electricity consumed in Turkey (Brander et al. 2011): 1009.75 gCO_2/kWh;
- the emission for natural gas boiler (www.biomassenergycentre.org.uk): 229 gCO_2/kWh;
- the emission [gCO_2/kWh] for air conditioner considering a EER equal to 3.2 (energy class B).

The computed reduction in CO_2 emission is shown in Table 6 if the GSHP system is compared to heating by gas boiler and cooling by air conditioning. Moreover Table 7 shows a simplistic comparison with the emission produced by a Fiat 500 1.3 Diesel (www.ilsole24ore.com).

Table 6. CO_2 emissions avoided with 1 km of tunnel activation for heating purposes.

	Winter	Summer	Total	Difference
Electricity need [MWh]	276	198	474	
Emission for GSHP heating [tCO_2/year]	279	200	479	-150
Emission for natural gas boiler [tCO_2/year]	317	-	317	
Emission for air conditioning [tCO_2/year]	-	312	312	
Total emissions for traditional systems [tCO_2/year]			629	+150

Table 7. Comparison with emission produced by a Fiat 500.

CO_2 savings [t/year]	CO_2 emission fiat 500 [kg/km]	Equivalent km covered [km]	Earth circumference [km]	Number of around the world laps
150	0.11	1363636.4	40075	34

The estimation of installation costs was performed with reference to a length of 280 m. Main installation costs are due to pipes installation, those embedded in the lining and those of the primary circuit. The total cost for a length of 280 m was estimated to be approximately 50,000 € that corresponds to a price of construction of less than 200 €/m, which is minor if compared to tunnel construction costs.

6_Conclusions

Thermal activation of urban tunnels is definitely a promising technique to exploit a renewable and local energy source. This paper has shown a possible application to the Istanbul metro line Dudullu-Bostanci by highlighting the steps needed to assess the energy potential, estimating the reduction on environmental impact when compared to traditional air conditioning systems and estimating the installation costs.

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COST BENEFIT ANALYSIS AND SMART GRIDS PROJECTS

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Abstract

Many studies have focused their attention on the zero-energy concept, presented by the European Directive 2010/31/EU about the energy performance of buildings. These studies are often concerned with the single building; only a few of them have verified the advantages of the zero-energy application to a larger scale, the district one. The concept of Net-Zero Energy District (NZED) is strictly connected to the Smart Grid one. Smart Grids are getting more and more important in the European context as they play a crucial role in the European strategies towards a low carbon energy future (JRC, 2012).

The term Smart Grid refers to a modernization of the electricity delivery system at a district level with the objective of integrating traditional upgrades and new grid technologies with renewable generation, storage, increased consumer participation, sensors (EPRI, 2011). The construction of a Smart Grid for an urban district involves substantial investments and it is envisioned to ensure high levels of the quality of electric power, to improve economic productivity and quality of life and to minimize environmental impacts.

The present paper aims at investigating the role of Cost Benefit Analysis in supporting decision-making processes in the context of projects related to Smart Grids application to retrofitted districts. Starting from a real case related to an urban district located in the city of Turin (Italy), the study illustrates the application of Cost Benefit Analysis for the selection of alternative strategies of intervention.

1_Introduction

The building sector is one of the major consumers of energy worldwide; it represents 40% of the total primary energy consumption and 36% of CO_2 emission in Europe (BPIE, 2011).

In the current context, politicians, stakeholders and even users are more aware of energy consumption problems in buildings, also thanks to the European Energy Performance of Building Directive (2010/31/EU-EPBD, European Parliament, 2010). EPBD introduced the nearly-Zero Energy Building (nZEB) term, suggested the application of a cost-optimal methodology to compare different energy scenarios and set the minimum energy requirements for buildings. Moreover, the European Commission is shifting the matter with steady increase from the single building level to the district one in order to hit the target of post-carbon cities. Sørnes et al. (2014) highlight the better performances of the zero-energy concept on a larger scale, rather than a single building, that improves the energy and greenhouse gas emission (GHG) saving, and could trigger an economy of scale to achieve cost optimality with current market prices. According to Marique and Reiter (2013), it is only combining a number of consumers that certain solutions or technologies (as district heating, cogeneration, biomass, and solar energy) can provide alternative strategies, which are not appropriate to a single consumer, either for technical or for economic reasons. Indeed, central supply can bring benefits, for example, in terms of investment savings, better efficiency and better possibilities for seasonal storage (BPIE, 2011).

Including co-benefits in project evaluations can help to select among alternative programs in preliminary energy design phases. Furthermore, the "Guide to Cost Benefit Analysis of Investment Projects" (EC, 2014) highlights the need to incorporate the socio-economic benefits inside the projects objective and evaluation, although it recognizes the difficulties in predicting and quantifying all the impacts involved. Electric Power Research Institute (EPRI, 2010) in USA and Joint Research Centre (Giordano et al., 2012) in Europe propose two main cost benefit analysis (CBA) methods to evaluate Smart Grid projects for urban districts. In both cases, the motivation behind the methodology development is the cost and benefits evaluation not only for utility, but also for customers and society in general.

The innovative approach of this research is that of taking the cost benefit analysis methods used to evaluate Smart Grid projects and modifying them in order to evaluate district retrofitting projects. In detail, it aims to investigate the Net-Zero Energy District (NZED) concept and tries to propose a calculation methodology to include several benefits related to different energy efficiency measures (EEMs) into decision-making framework.
According to EU directives and the two methods developed by EPRI and JRC, it is necessary to extend the point of view to policy makers, interested in determining net social benefits generated by a project. To do that, a cost benefit analysis approach was used, including within the study, for examples, costs like the CO_2 emissions, and the so called co-benefits (e.g., green jobs, asset value), considering the contribution that the project could give to the society economic wealth.
In the end, the employed methodology was validated through its application to a case study; a selected district in Turin (Italy) was hypothetically transformed into a Net-Zero Energy District and four different scenarios were compared in order to identify the best solution from a socio-economic point of view.

2_Methodological framework

2.1_Evaluation of co-benefits

International Energy Agency publication (IEA, 2012) helps to understand the multiple relationships that exist between a project of energy efficiency and not only the traditional measures for reduced energy demand and greenhouse gas (GHG) emissions, but also other aspects including externalities.
In this sense, the benefits of efficiency use of energy generally fall not just on system utility. They could accrue directly to the participating individual homes and businesses that install EEM. Moreover, they extend to the society, to the community involved in the process.
Theoretically, for each of the following co-benefits identified, through a literature review (Table 1), a monetary value could be estimated. Some selected impacts were quantified in physical units (e.g., avoided ton of CO_2, number of additional full-time jobs created, etc.), and then translated into a monetary value, to be incorporated in the cost benefit analysis.

Table 1. Co-impacts and supporting-literature.

Co-benefit	Description	Authors
Energy savings	Energy saving is a direct benefit resulting from increased energy efficiency. The energy issue is one of the major European challenges and it must take into account global markets dynamics, government policies and the industry and households consumers. According to some studies, it is interesting to note how the energy saving benefit could be collected not only by private user, but by public user too; in fact in case of public buildings, it would be useful to assess the monetary benefit as resources available for other community activities.	Copenhagen Economics, 2012; EC, 2014
Indoor Comfort	Interventions aimed at improving the building energy performances could also determine an increase of indoor comfort and so an improvement of physical conditions and air quality, raising occupants' satisfaction level. The indoor comfort plays different rules according to the environment in which the EEMs are implemented. Indeed, researches have demonstrated that air quality improvement in the offices enhances working efficiency too.	Fang et al., 2011; EC, 2014; World Green Building Council, 2015
GHG emissions	Energy efficiency has an important role, acknowledged at national and European level, with regard to the reduction of greenhouse gas emissions (GHG), in line with international commitments to tackle climate change. In several studies, the GHG emissions reduction are considered in terms of avoided damage costs of the impacts of climate change.	European Parliament, 2010; Copenhagen Economics, 2012
Health benefits	Studies highlight the impact of "cold" houses on health and the potential effects of heating and insulation on well-being. Health benefits can be translated in the reduction of the diseases and mortality, and thus lower care costs and reduced risks regarding this issue. In addition to that, EMMs influence the improvement of workers productivity and the overall quality of life.	Liddell et al., 2011; Threlfall, 2011
Green Jobs	Creating new jobs and fighting unemployment are nowadays increasingly considered as a positive externality. EEMs investments have positive macroeconomic impacts in terms of additional economic growth and employment creation and offer the opportunity of goods and services production according to the green economy market. In this light, it is necessary to take into account not only the new jobs created directly, but also induced ones.	Tourkolias et al., 2009; Ürge-Vorsatz et al., 2011; Copenhagen Economics, 2012
Energy security	Political instability highlights that energy efficiency is a key point to reducing the risk related to the source unavailability. Italy has set important objectives through the National Energy Strategy (2013) to reach a more competitive and sustainable energy. The main challenges are to improve the security of supply, to reduce dependence from foreign countries, and to better respond to critical events.	Maibach et al., 2007; Hedenus et al., 2010
Asset value	The EEMs have positive effects in terms of real estate valorisation and respond to the current green economy demands. Real estate appraisal experts consider that this will have an impact on the structure of the sector, as well as on methods and assessment tools. The outputs of some research show that consumers appreciate high-energy performance class (EPC).	Popescu et al., 2012; Bottero, Bravi, 2014; Copiello and Bonifaci, 2015
Energy interruptions	The electric energy storage systems play a strategic role in supporting the generation and development of the smart grid. In particular, the association of sources that let the electricity self-production and the use of storage batteries allow the reduction of the energy supply interruptions.	Bertazzi et al, 2005; EPRI, 2010; Giordano et al., 2012

2.2_Cost-Benefit Analysis

According to EC (2014), Cost Benefit Analysis (CBA) is an analytical tool that is used in investment decisions in order to assess the welfare changes attributable to alternative projects and to select efficient resources allocation from the point of view of the society's convenience. CBA is developed through subsequent steps as follows: 1) identification of costs and benefits of the project; 2) estimation of the monetary values; 3) distribution of the estimated costs and benefits over the time and construction of the cash flow; 4) definition of the discount rate; 5) calculation of the performance indicators. With specific reference to the performance economic indicators, these are represented by the Net Present Value (NPV) and the benefit/cost ratio (B/C). The NPV aggregates of all costs, revenues, impacts discounted to reflect the value in the same period and the B/C concerns the discount value of revenues and positive impacts divided by the value costs and negative impacts discounted. The benefit/cost ration is very strictly connected to the Social Return on Investment (SROI) (Nicholls et al., 2012). It is calculated dividing the sum of the discounted benefits flows by the sum of the discounted costs flows (1), obtaining a dimensionless ratio:

$$SROI = \frac{\sum \frac{B}{(1+r)^t}}{\sum \frac{C}{(1+r)^t}} \tag{1}$$

where B is the benefits flows, C is the costs flows, r is the discount social rate and t represents the time. The SROI aims to make a clear relationship between the monetary investment to make a project, and the impacts return, translated into monetary terms.

3_Case study: a sustainable district in Turin

The neighbourhood chosen for the methodology validation is a residential district in the municipality of Turin (Northern Italy), characterized by mixing of different buildings for typology and use. Firstly this district was chosen because of buildings low thermal properties, since they were built before 1980. Secondly, since this neighbourhood is not connected to district heating, and there are no provisions for it, this case study represents a good opportunity to experiment its application.

Four retrofit scenarios, characterized by different energy efficiency measures applied to buildings envelope and various configurations of heating generation, were defined for the district (Table 2).

The district buildings were clustered in 5 typologies, according with their geometrical and thermo-physical features and their construction period by TABULA database (Corrado et al., 2014). Two levels of building envelope retrofit were considered (according to the limits prescribed by D.G.R. n.46-11968 of the Piedmont Region): a “standard” refurbishment, applying measures which are commonly used on the market; an “advanced” refurbishment, applying measures which reflect the best available technologies. The energy needs for space heating related to these two retrofit levels were extrapolated from TABULA database, as the need for domestic hot water production.

As regards EEMs system, all scenarios assume district heating as solution coupled to the cogeneration, in order to cover a large part of the electrical needs, but with different energy carrier (biomass and natural gas) and with different generation efficiencies.

		Envelope EEMs	
		Standard	Advanced
Generation EEMs	District Heating - Biomass Oil Circuit Recloser cogeneration system - Biomass thermal system - Photovoltaic system	Scenario 1	Scenario 2
	District Heating - Gas turbine cogeneration system - Gas thermal system - Photovoltaic system	Scenario 3	Scenario 4

Table 2. Energy retrofit scenarios.

4_Estimation of co-benefits

4.1_Energy performance and environmental impacts

A first issue refers to the evaluation of district energy performance for the four scenarios. To do this, it was estimated the non-renewable primary energy related to the existing district (so, without energy retrofit) and to the four hypothetical alternative scenarios, calculated according to the quasi-steady state method described in the Italian Standard UNI/TS 11300 (UNI, 2014-1; 2014-2). For the environmental impact, CO_2 emissions were quantified from these consumption data. Thanks to CO_2 factors emission given by UNI/TS 11300 (UNI, 2012) for each energy carrier, the produced CO_2 was calculated by following formula (2):

$$M_{del,ICO_2} = Q_{del,I} \times k_{em,I} \tag{2}$$

where M_{del,ICO_2} is the CO_2 amount of energy carrier, $Q_{del,I}$ is the specific production of energy carrier, $k_{em,I}$ is the CO_2 emission factor. This value is multiplied for the expected prices per ton CO_2 equivalent, estimated by EPBD recast, for each scenario.

4.2_Evaluation of energy savings and running benefits

The energy savings benefit was calculated according with European Commission (EC, 2014) method, where the project benefit is presented by the saved costs. The variation in economic costs of the energy source/fuel was calculated comparing the existing district with the alternative scenarios. This bill reduction would absolutely lead to a decrease of revenue in government spending, due to an energy tax reduction. It was considered as a cost for public finance, estimated as the 10% (the energy VAT value) of state of art energy cost. In this research, the running benefits were taken into account where it is possible to identify the maintenance and disposal costs avoided thanks to EMMs. Mainly, the maintenance costs were estimated referring to EN 15459/2007 (CEN, 2007), which defines these cost as a percentage of initial investment cost for buildings and district system elements. Where disposal costs exist, these were calculated, for example in biomass systems, by the quantity of ash produced (in ton) multiplied for disposal cost for ton (€/ton).

4.3_Estimation of real estate market value

This benefit was calculated by the hedonic price approach, proposed by Bottero and Bravi (2014). According to this method, the real estate price can be considered as a set of attributes, able to influence its value. At first a market analysis was carried out on around 160 real estate listing sites on case study microzone, and the prices and features of the properties were tabulated. Some important buildings features (as surface, floor, apartment condition, location and Energy Performance Certificate [EPC]) were selected and inserted into multiple regression function. Thanks to it, it was possible to assess the relationship between the dependent variable (price) and one or more independent variables (building attributes) and to estimate the willingness to pay for different EPC levels, isolating its coefficient. In this case, the

EPC value is equal to €9˙600 per considered apartment. The benefit general value was calculated multiplying the EPC coefficient value for the number of buildings energy class changes multiplied by the estimated number of apartments in the area under investigation.

4.4_Description of Green Jobs creation

The new jobs created by building retrofit were estimated by the research developed by Janssenand Staniaszek (2012). Taking into account the value of 19 net new jobs for 1 Mln invested for envelope EEM, it was possible multiplied this value for a shadow wage. This was estimated according to EC (2014), which highlights the unemployment rate influence on market. The shadow wage (SW) was determined by (3):

$$SW = W \times (1 - t) \times (1 - u) \tag{3}$$

where W is the average construction gross annual salary estimated by ISTAT (2014), t is the income tax rate (equal to 20% for Italy), and u is the unemployment rate of the region considered (10,6% in Piedmont). In regard to EEMs system, reference is made to a study developed by the Department of Energy of Politecnico di Milano (2012) that quantifies the staff annual cost for each measure. In according to Copenhagen Economics (2012), this study identifies the benefit regarding the unemployment benefit reduction. Taking into account the gross salary per month, it was possible to calculate the subsidy avoided for every single worker employed. The Italian subsidy is called NASPI (Nuova prestazione di Assicurazione Sociale per l'impiego) and it was calculated for monthly salaries above to €1˙195 by following formula (4):

$$NASPI = (W \times 0.75) + [(W - 1˙195) \times 0.25] \tag{4}$$

where W is the market monthly salary.

4.5_Results

The percentages on the graph of Figure 1 show the reduction in non-renewable primary energy (in grey), and in CO_2 emissions terms (in black) according to each scenario respect to the existing district. Scenario 1 and scenario 2 are the most sustainable one in terms of consumption and emissions. Indeed,

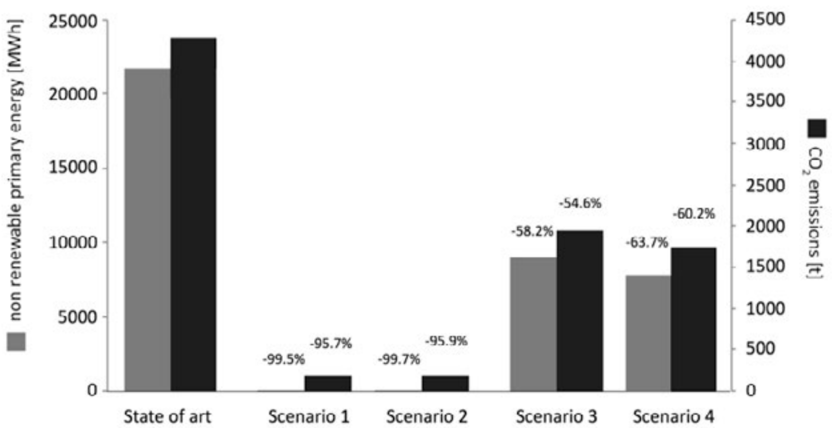
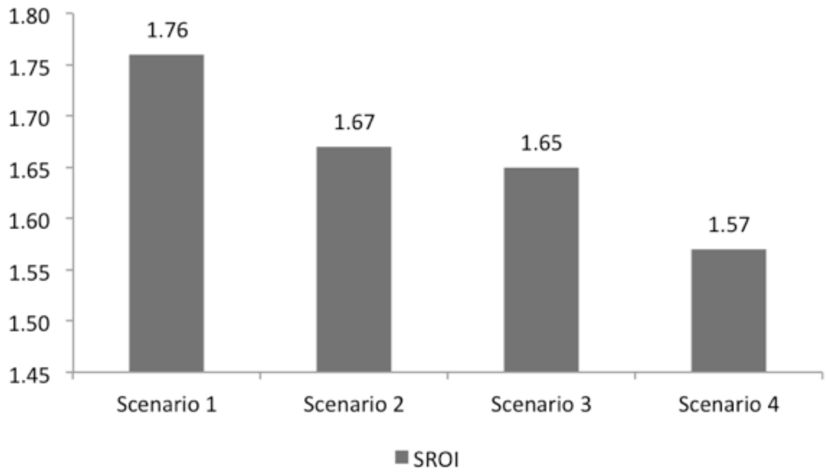


Figure 1. Non renewable primary energy (in grey) and CO_2 emissions (in black) comparison for existing district and for each strategies.

they can reach the Zero-Carbon City target: that is the climate neutrality with nearly-zero emissions.
Trying to extend the analysis to a macroeconomic scale, it is necessary to include the co-benefits calculated thanks to the proposed methodology. In addition to estimating the co-benefits, it was also necessary to value the initial costs of the four considered scenarios. In this case, the parametric (or synthetic) construction cost estimate has been applied and an approximated value of the investment costs has been obtained. Once estimated all costs and benefits, and set the period of calculation, it was possible to fill in the table of the CBA for all scenarios. The cash flow was calculated and, using the social discount rate, it was updated to estimate indicators of economic performance: the NPV and the Social Return on Investment (SROI). In particular, the SROI is able to assess in monetary terms not only the economic value generated, but also the social and environmental one.
The result of the analysis showed that the most efficient scenario in socio-economic terms is the number 1 (Figure 2). Indeed, high investment and management costs characterize this scenario, but on the other hand it also guarantees higher economic returns to society, particularly low emissions costs and a greater number of created net new jobs.

Figure 2. SROI value for each scenario.



5_Conclusions

Many studies have recognized co-impacts from projects related to green energy, different from the effects that commonly are considered. The main challenge of this research is to provide methodological guidance for the identification, quantification and monetization of co-impacts, and their insertion in a cost benefit analysis to support decision-making, in order to identify a single evaluation index that gives a comparable value for each efficiency strategy, the Social Return on Investment (SROI). To validate this methodology, it was applied to a district energy retrofit case study, located in Turin. The SROI results showed that the most convenient scenario in socio-economic terms is the first one, characterized by a standard level of envelope retrofit, and by EMM system fuelled by biomass. From this study it is possible to highlight that, in addition to energy and money savings, these design choices can greatly reduce the impact on the environment and CO_2 emission, thanks to the use of renewable sources to meet the heating and electricity demand, in line

with the European decarbonisation objective. Another reason that favoured this scenario is the benefit of new jobs created by retrofit interventions, a major number of workers employed compared to scenarios with fossil fuels.
Finally, it is possible to say that the developed methodology is effective to support decision-making for districts retrofit. Indeed, the analysis performed for the different scenarios suggests that co-benefits have significant impacts as they have the potential to change significantly the outcome of the evaluation of energy efficiency measures, not only economically, but also environmentally and socially, covering a bigger share than the financial revenues of the project.
In this first application of the methodology, estimates were rough, and they will be refined. Firstly, the estimate of the market value is at the centre of large-scale studies by the international literature that proposes more sophisticated approaches to quantify this benefit. Secondly, best results could be obtained if other impacts will be included within the methodology the full range of externalities. For example, impacts that were not considered in this analysis are the health and well-being ones; the literature regarding the quantification and monetization of these benefits is still immature or almost non-existent, especially referred to Italian context. Another possible development is to create tools to facilitate methodology application, as models of spatial hedonic pricing, in order to create databases, through for example geographic information system (GIS). Moreover, given the fragmentation of users (owner, investor, etc.) within a district, such analyses may serve to guide the choices in redevelopment, allowing the decision maker to trigger the most convenient and profitable process among the others, including the effects that otherwise would not be taken into account in the project evaluation. Finally, it would be interesting to explore the decision problem under investigation making use of other evaluation methodologies, such as Multi-Criteria Analysis (MCA, Roy and Bouyssou, 1995; Belton and Stewart, 2002; Figueira et al., 2005). MCA would allow to include in the analysis all the relevant impacts of NZED, and they would be able to help decision maker to integrate alternative options. The MCA resulted simpler to apply compared to CBA, because the translation into monetary value of the full range of costs and benefits were not required (Beria et al., 2012).

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AN OVERVIEW OF AERIAL ROPEWAY TRANSIT AND ITS POTENTIAL IN URBAN ENVIRONMENTS

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Abstract

Mass transit systems present cities with significant potential advantages for economic, social, and environmental improvement (Lane 2008). However, geographical and topographical barriers and infrastructure costs may not permit the implementation of conventional public transportation systems such as light rail and buses (Pojani and Stead 2015). In these instances, city planners may look at unconventional modes of transportation to serve residents' needs. Aerial cable systems, or urban gondolas, a type of aerial transportation mode in which passengers are transported in a cabin that is suspended and pulled by cables, are attracting attention as one of the solutions to such cases. The gondola lines are cheaper than light rail, can navigate more topographically challenging terrains than buses, and could offer important environmental benefits because of their low greenhouse gas emissions, energy use, and noise pollution (Tahmasseby and Kattan 2014, Bergerhoff and Perschon 2013). Using aerial ropeways in urban environments has gained more attention worldwide, and cities such as Medellin and Caracas have incorporated gondolas and aerial tramways into their public transport networks creating efficient urban transport systems (Alshalalfah, Shalaby, and Dale 2014). This study attempts to shed some light on aerial ropeways technology from an urban planning perspective by presenting experiences with this technology and including the reasons for building these systems and their service and operational characteristics as well as other case-specific information. The paper concludes with an assessment of experiences with these systems including their benefits and limitations.

1_Introduction

'Cable-propelled transit' (CPT), in particular detachable aerial ropeways are widely employed as transportation systems in alpine areas. In recent years, these transport systems have been attracting attention as viable mass transit alternatives in urban environments and are no longer a niche public transportation technology (Hoffmann 2006, Alshalalfah, Shalaby, and Dale 2014, Tahmasseby and Kattan 2014). Cable cars systems compete with performance characteristics of other more common urban transport technologies and have the potential to enhance the existing transport provision in cities (O'Connor and Dale 2011). While many applications can be found as transportation systems in airport facilities, and to provide access to tourist attractions, several metropolitan areas have even incorporated gondolas and aerial tramways into their public transport networks. This paper focuses on aerial ropeway systems that operate as a mass transit service (similar to buses, BRT, LRT, etc.) and are part of the public transit systems in their respective cities. Therefore, the case studies presented in the paper concern systems that are used as a public transit service.

2_Background

A ropeway is an eco-friendly type of transportation mode in which passengers and shipment are transported in cabins that are propelled by steel cables. The principle of the cable-drawn transport scheme is not a new concept and has been applied mostly in terrain-challenged recreational contexts to transport skiers and tourists to mountain resorts and leisure parks. Technology and operational concepts, however, have evolved overtime to make them a reasonable and attractive alternative for mainstream urban public transport where conventional transit service was deemed very difficult or infeasible to implement (Bergerhoff and Perschon 2013, Alshalalfah, Shalaby, and Dale 2014). Recent systems are classified according to the type of track (carrier) used (Hoffmann 2006). Top supported systems, also known as aerial cable systems, are supported from above via a cable (which may or may not be the same cable that propels the cabins – this varies by technology). Bottom supported systems are supported by tracks or rails underneath, yet are still propelled by a cable (The gondola project 2016). There are two types of aerial ropeways: the "aerial tramway" (telepherique) with two large cabins permanently attached to each leg of the pulling cable - the cable turns in one direction and stops when the reaching the stations; it then turns to the other direction; and the "gondolas" (telecabines), with a constantly revolving unidirectional pulling cable, to which smaller gondolas are attached and detached when entering and travelling through a station (Bergerhoff and Perschon 2013). The industry has made significant improvements in the performance and capabilities of the technology, including the tricable configuration, faster line speeds and standardized intermediate and turning stations. Monocable technology is a term is used when a single cable is used to propel and support the cars (examples: Medellín in Colombia and Caracas in Venezuela). This type of technology uses small cars (generally fewer than 16 places) and limits the distances between pylons (maximal distance: 600 to 800 metres). Generally, the cost for a monocable detachable gondola system is between $5-20 million (US) / km (The gondola project 2016). Bicable or tricable technology terms are used when one cable is used to pull the cars while one or two others support their weight (example: Coblenz in Germany). These types of system allow longer distances between pylons (up to several kilometres) and larger cars. Monocable, bicable and tricable aerial ropeways offer several advantages when compared to traditional mass transit modes: high safety, high carrying capacity, long routes can be implemented (up to approx. 6 km/section), continuous passenger flows thanks to the constant movement, low space requirement along the route, no overlap with other forms of transportation (Hoffmann 2006, Alshalalfah, Shalaby, and Dale 2014) . Further advantages of the bicable and tricable aerial ropeway are that very long rope spans are feasible (up to approx. 1,500 m). Recent advancements in aerial cable systems also assure high wind stability.

Ropeways are extremely adaptable to the terrain and represent an optimal transport solution for challenging topographical landscapes such as hilly terrains (Alshalalfah, Shalaby, and Dale 2014). However, even on flat land, ropeways have the capacity to overcome many other types of natural and manmade obstacles, such as rivers, lagoons and estuaries, harbours, railways and motorways. Depending on the possibility to place intermediate pylons, even city traffic be overcome without the construction of surface or underground infrastructures (Bergerhoff and Perschon 2013). In some areas, these cable car systems have emerged as an optimal way to connect informal settlements that got established over the past decades along steep slopes and hilly terrains and where public transport supply is largely underdeveloped. The major potential of aerial ropeway systems is seen in the significant increase in accessibility between these settlements and other locations within the urban fabric, supporting social inclusion and access to work and education opportunities (Dávila and Daste 2011, Bocarejo et al. 2014). Although many existing gondolas systems are located in developing countries in South America, proposals are in the works in a number of urban areas in the US including metro Atlanta, New York, Washington DC, San Diego, and St. Petersburg, Florida (Gurley 2016)

Additionally, integrating a cable car system into the existing transport infrastructure is relatively inexpensive compared to light rail or bus transit costs (see Figure 1) and it can be constructed quickly (London's Emirates Airline which crosses the River Thames, for example, was open for business 10 months after construction began). Most maintenance task can be carry out outside of revenue service (detachable gondolas can be garaged), although the system may have to be shut down few days a year for more complex safety operations measures (Certu-STRMTG-CETE 2011).

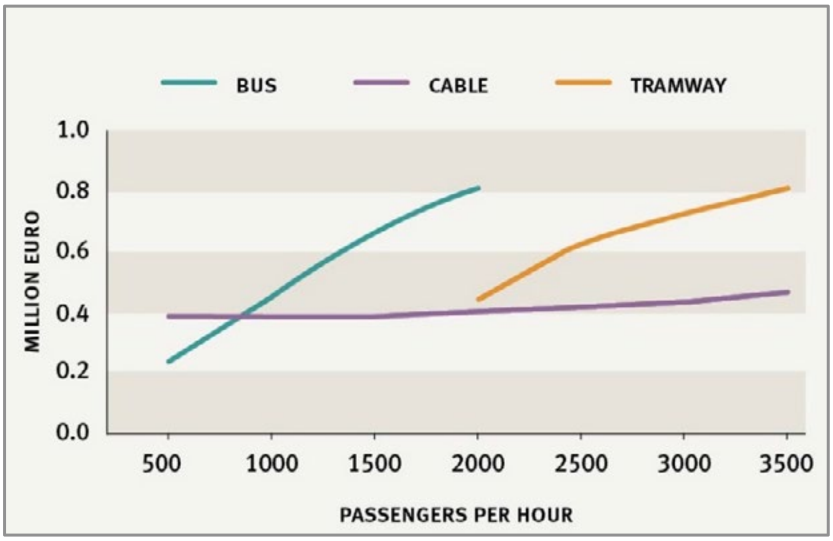

Figure 1. Indicative comparative cost based on operating cost of bus, tramway and ropeway in Grenoble, France (source: http://www.steerdaviesgleave.com/news-and-insights/cable-cars).

In terms of capacity, an aerial tramway service is comparable to that of a standard bus, while the gondola systems provide capacities comparable to small tramways (See Figure 2). Its operation is automated and allows for adapting capacity to demand by modifying the speed of the traction cable (Certu-STRMTG-CETE 2011), although the maximum capacity of cable car systems is strictly limited by the maximal weight the cars and the cables can carry since cable supports and other civil engineering components are sized for a predetermined weight (Alshalalfah, Shalaby, and Dale 2014).

More and more of these transit systems are appearing in cities all over the world (Bochum in Germany, Istanbul in Turkey and La Paz in Bolivia are only some of the latest examples). While these experiments are encouraging, it is worth considering the challenges of developing an aerial ropeway transportation system. One of the biggest concern is that it cannot be modified or be difficult to integrate with existing transit systems because lines cannot branch off or turn. However, as shown in Medellin, carefully planned ropeway

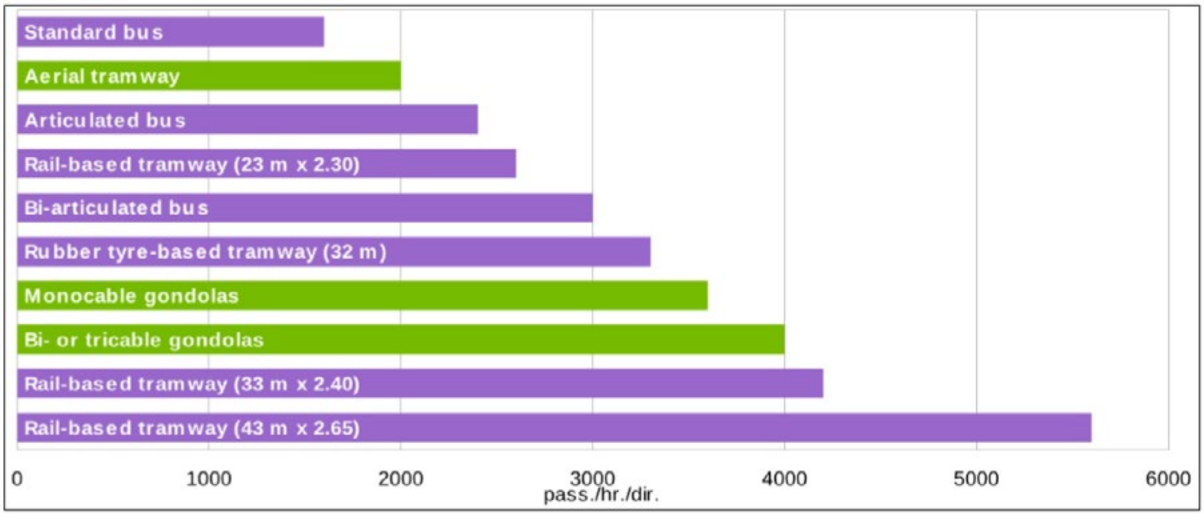

Figure 2. Capacity pphpd (passengers per hour per direction) of typical urban transport systems (Bergerhoff and Perschon 2013).

systems fully integrated with the public transit network, providing passengers with the ability to transfer seamlessly to local metro lines, can overcome this issue.

Disadvantages of aerial ropeways systems include weather sensitivity, as safe operation may not be maintained in the event of extremely high winds (Hoffmann 2006). However, recent technology improvements have made gondolas and aerial tramways extremely safe and able to perform extremely well in windy conditions.

3_Urban aerial ropeway systems examples

3.1_Medellin, Colombia Metrocable

This new wave of urban aerial ropeways construction kicked off in Medellín, Colombia, which was the first city in the world to use the new system in an urban environment as a form of public transport to serve underprivileged hilltop neighborhoods. Medellín is presently home to three Metrocables, or aerial cable-car lines. Linea J and Linea K are both urban commuter lines that link directly to the city's rail system. Linea L connects residents to Parque Arvi, a large park located on the outskirts of town. Construction of

Figure 3. Aerial ropeway in Medellin, Colombia (Source: Getty Image).

the new system, the Metrocable Medellín, was completed in 2004. Soon, the idea caught on across Latin America, and cable cars began hauling passengers in major cities such as Caracas, Manizales, Rio de Janeiro, and most recently La Paz, Bolivia.

The first line (Linea K) opened in 2004 and is considered the first fully integrated urban aerial cable car system in the world. Linea K soon started running at full capacity and is widely perceived as a success, thus prompting other cities in Colombia and Latin America, such as Rio de Janeiro and Caracas, to launch similar systems (Dávila and Daste 2011). Both Metrocable lines J and K connect neighborhoods located in the mountain foothills that surround the city. While Linea K is located in a well-established and populous area, Linea J extends into a barrio (neighborhood) that is currently experiencing rapid growth. Both lines have had positive impacts on their surrounding area improving accessibility to outside destinations and decreasing commuting time.

Figure 4. Medellín's Metro system (Source: https://www.metrodemedellin.gov.co).

The Metrocable was designed as part of an integrated urban project (Proyecto Urbano Integrado, PUI), and led by the local government-owned mass transit authority (Empresa Transporte Massivo, EMTVA). The project was supplemented by the construction and upgrading of community facilities and public spaces and efforts to involve residents in the planning and implementation. This approach is aligned with wider urban-planning goals of improving the living conditions of residents within informal settlements and aims at demonstrating that after decades of neglect, city planning and politics are addressing the problems of these communities at last (Dávila and Daste 2011).

	Line K	Line J	Line L
Launch date	2004	2008	2010
Length	2,072 m	2,782 m	4,469 m
Commercial speed	5 m/s	5 m/s	6 m/s
Hourly capacity	3,000 pphpd	3,000 pphpd	1,200 pphpd
Total cost	US$ 24 million	US$ 47 million	US$ 21 million
Finance source	Municipality: 55% Metro: 45%	Municipality: 73% Metro: 27%	Municipality: 38 Metro: 34% Provincial government: 17% Ministry of Transport: 9% Other: 2%
Fare integrated with metro	Yes	Yes	No

Table 1. Metrocable lines: basic information (Source: https://www.metrodemedellin.gov.co/).

3.2_Caracas, Venezuela

The first aerial ropeway Caracas dates back to 1952, although the cable car transportation system was decommissioned in the late 1970's and re-built (with extension) by 2010 to a length of 3.5 km, serviced by 70 gondolas, following the success of the "Metrocable" of Medellin. As in Medellín, the aerial ropeway systems in Caracas were planned as feeders to the existing rail based high capacity public transport line connecting hillside neighborhoods to the remaining urban fabric. The first gondola line in Caracas was planned to connect the community of San Agustin to Central Park (Parque Central) Station, where it connects to the subway system (Bergerhoff and Perschon 2013, Alshalalfah, Shalaby, and Dale 2014). Like other communities with a history of crime and poverty in the Venezuelan capital, San Agustin is one of the poorest and socially most challenged neighborhoods, spreading up the steep mountainside, and making transport by vehicle difficult and often unfeasible. Urban Think Tank, and architectural firm, made a proposal to the city to build a cable car system linking San Augustin with Caracas's public transit system. The plan, which was developed based on site surveys, community workshops, and other on-the-ground fieldwork by the architects, focuses on the cable car system but calls for "plug-in" buildings—structures attached to each station housing cultural and recreational programs—as well as other, smaller-scale interventions close by. As a result, unlike the Medellin systems, Caracas Metrocable features enormous stations that included social facilities such as gymnasiums, police stations, community centres and markets. The Caracas Metrocable is also the first in the world to feature extreme 90 degree turning radii at stations (The gondola project 2016).

Figure 5. View of Hornos de Cal station, Caracas (source: http://www.moma.org/interactives/exhibitions/2010/smallscalebigchange/projects/metro_cable).

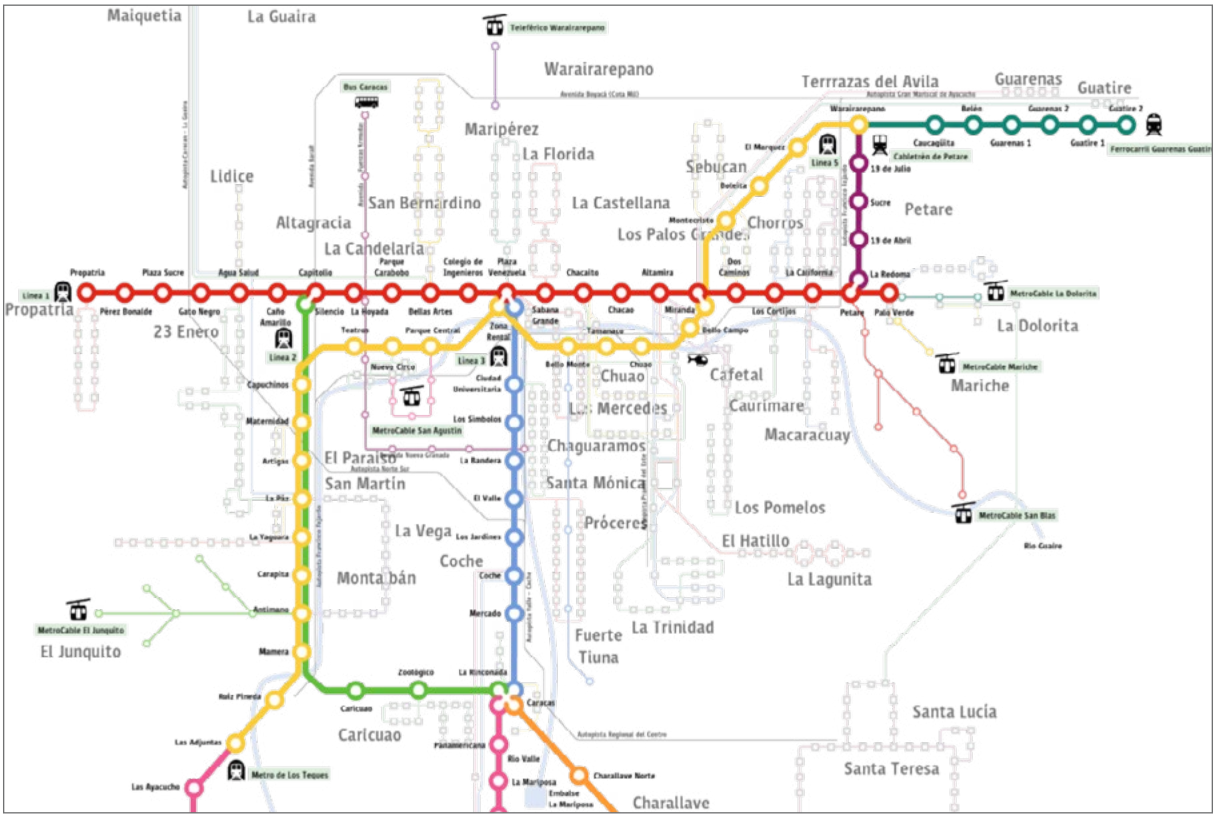

Figure 6: Caracas map of public transport (partial) (source: https://commons.wikimedia.org/).

4_Conclusions

The introduction of new transit modes into the array of urban transit systems has been an area of great interest to transit agencies, inventors, manufacturers and even governments. The need for transit modes for specific conditions has led to the introduction of entirely new and unconventional modes, such as aerial ropeway systems. Technical innovation has made aerial ropeway systems a comfortable, high capacity public transport system, which can create direct links without need of massive infrastructure. As seen in Medellín and Caracas, what makes cable car schemes work in an urban context is their holistic approach with strong emphases of community development and their integration with the rest of the transport network, particularly – but not exclusively – public transport services. In both these cities, the aerial ropeway system was not planned alone but as part of a bigger urban regeneration project aimed at improving quality of life in the most deprived and underserved areas of the city.

It is worth mentioning that despite most of the existing aerial ropeway applications are in topographically challenging regions, such as mountain terrain, the technology could also be considered as a viable option for applications in space-constrained urban spaces such as downtown areas, supplementing the set of technological tools available to transit planners and decision makers. Reduction of road congestion, parking problems, noise and air pollution (gondolas do not have motors and run on electricity) are few of the most relevant reasons which may spur further development of aerial ropeway transport systems in urban areas. Aerial ropeway systems market has the potential to become the dominant market for the cable industry in the future as cities worldwide are beginning to realize the potential of urban gondolas as part of a solution to their transportation needs. Especially in cities in developing countries without rail or BRT systems, ropeways can change and improve urban mobility and help achieve sustainability and equity goals. This presents researchers and scholars with the opportunity to start developing more case studies and performance analyses that may support further diffusion of urban aerial ropeway transit systems.

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Decision Making Methods and Tools at Urban Scale

Tools, methods and experiences for an integrated and sustainable territorial government

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This text is the result of joint work on which the three authors agree and it's by the three authors in equal parts.

Abstract

Urban planning and design for post-carbon sustainable city requires a major connection between the new scientific paradigms of environmental disciplines and useful/communicative indicators to steer local policies.
Nowadays the spatially explicit assessment of Ecosystem Services (ES) and their flows can effectively support the decision making process for sustainable development. Thus the methodology of considering environmental sustainability during planning phases should be hold in plan's construction and integrated during the decision making process at urban scale, also using Co-planning method.
The paper experienced the recent research innovations made by DIST for LIFE program SAM4CP, where preliminary output of ES mapping were used as proxy for the identification of high value areas to be planned.
Inside it is presented a methodology of integration betweenmapsofbiophysical/economical ES values using InVEST software as a tool for geographic, economic and ecological accounting. The mapping activity, related to Land Cover/Land Use information for a context based case of was used to supportthe preliminary approach to co- planning activityfor multilevel governance, especially .among consensus building approach and the Co-planning Conference.
Innovations are discussed both by processual andtechnical sides: (i) the urban planning activity founded upon the Co-planning method and supported by such analysis, allowed policy makers to go into the substance for reconsider their strategies for sustainable territorial government and (ii)the scientific contribution of the research on mapping ES demonstrates that approach is today fully incorporated on local tools for land management.

1_Introduction

The integration of urban planning and ecology is recently increased and nowadays it is considered a foundation of the discipline: it sets new fields of competence of the municipal/local plan, new disciplinary partnerships and emerges as a result of the introduction of new laws, both national and regional.
Since it is necessary to overcome the "protection/defense" approach of territory, environment and landscape, the plan is able to be the instrument of a new strategy for the unified government of city, territory and environment that integrates urban planning and ecology (Campos Venuti, 1994).
Therefore it is necessary to redefine the overall strategy of the plan,and its contents,renewing and extending their knowledge that underpin its implementation, using new skills and methods of analysis.
Within this premises, the approach of mapping and modelling ES has rapidly increased (Hayha& Franzese, 2014). The ES approach can help to evaluate the effect of a project or policy on soil ecosystems,thus it canhelp to better communicate and visualize planningoutcomes to policy makers, supporting environmental planning decisions,and designing sustainableland uses (Maes, et al., 2012). In terms of energy efficiency, a deep ES modelling should support a better balance of sustainable use of land: the monitoring of flows in terms of ES is a basilar energy related information to better achieve sustainability in planning.

The LIFE project SAM4CP[1] aims to connect the scientific knowledge on ES allowing a better territorial decision mechanism. The project leads to include the ecological assessmentof soil within itseconomic valuealso accountingalternativeland-use scenario. This require a high degree "mapping" ESknowledge, using accurate and precise dataset to support traditionalenvironmental analysis for land use planning(Benini, et al., 2010). This is why a group of DIST -Politecnico di Torino expertise[2] is working to develop the technical actions to support planning decision. Such methodology require also technical innovations: a new software for ES mapping has been used for construct land use scenariosanda new participatory planning process has been supported by an ES biophysical and economic assessment.

The project aims to capture the "flows of value" that a land use variation produce to the initial stock, going beyondthe traditional approach of Land Use Change Analysis (Keller, et al., 2015). It is the "quality", rather than the "quantity" of consumed soil to be analysed by the lens of the project. Such information is crucial for a better integration of sustainable/resilient strategy of land use managementin terms of energy systems: only if the knowledge on flows of ES is deep than strategies of mitigation and compensation measures for land transformation can be activated (European Commission, 2012).

As introduced, the mapping process is fundamental to estimate the current (baseline scenario) and expected trends in ES values and their economic assessment. The economic evaluation of ES is going to became crucial for raising environmental policy awareness (de Groot, et al., 2002; Tol, 2005; Gomes Lopes & al., 2015; Baral & al, 2014), but still requires a better connection to the biophysical assessment of ES(Costanza & al., 1997; Tol, 2005). Measuring ES in monetary terms can help make them "visible" and ensure that the benefits of biodiversity are effectively taken into account forplanning processes. The overall target of the project is to connect the assessment results with the real planning processes in defined case studies. Nonetheless, the project will guarantee a high degree of shared knowledge between stakeholders and public administration at different level. Such approach, which is called "co-planning", allows to steer policies at different level, modify the existent strategies for environmental sustainable land use planning ad to define new ones, starting from the acquired knowledge on soil properties and its ecological and economic values.

At the stage the project is in the middle of its implementation. This limitation should not guarantee that results of interaction between different actions will be fully achieved. In particular, the integration between evaluation and planning activity is not tested yet trough practical experiences. Nevertheless, the project has already defined the methodology regarding the support of planning activity by the integration with ES evaluation: it means that the way how the stakeholders and the public administrations make decision process has to be supported by the ES analytical framework. Moreover, such kind of framework needs to be constructed with a bottom-up approach where local stakeholders and citizens have an importantrole in the definition of ecosystem's value. Finally, according to the Project, the above mentioned activities will be supported by actions of consensus-building also aimed to inform local actors and to spread the importance of considering ES into planning disciplines.

[1] Title of the Project: Soil Administration Model for Community Profit. Project leader: Città Metropolitana di Torinoresponsible for the actions 3, 4 as well as a management and administrative management of the project; Partner (1): Politecnico di Torino, Inter University Department of Regional and Urban Studies and Planning; Partner (2): ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale; Partner (3): CREA, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria.

[2] The DIST research group is composed by: Prof Carlo Alberto Barbieri (Scientific Responsable), Prof. Giuseppe Cinà, Prof. Angioletta Voghera; with an operative team of research fellows composed by Dr. Carolina Giaimo, Dr. Dafne Regis and Dr. Stefano Salata.

2_The government of land use change

The territorial government is a wide concept composed both by technical and political skill and expertise that can't be addressed to a "discipline" in the traditional sense: therefore it can't be limited to the regulation of land use and building. It represents an integrated system of theories and practicesmade by knowledge and experiences with a properhorizontal and multiscalar"functional role", which exceeds the typical skills fragmentation of urban planning disciplines. Indeed, the territorial government includes a huge amount of expertise: environment, landscape, soil conservation, ecosystems protection, enhancement of cultural and environmental heritage, socio-economic development, mobility and territorial infrastructure (Barbieri, 2015).

Therefore, it's necessary to adopt rules and procedures for innovative urban and territorial planning, to support policies for the protection, enhancement and qualification of settlement, for urban regeneration and reduction of land take as well as governing climate change. But innovations for sustainability requiresto assume the principle of subsidiary and to recognize that territorial government is an integrated "horizontal" process rather than an"hierarchic system" composed byseparated plans drawn up by different and separated institutions.

By the way, there is a widespread awareness that the hierarchical planning model (and related procedures) based on the approval through dirigisme and indicator-based approach, is now obsolete and inadequate (Barbieri, Giaimo, 2015). Therefore, the sustainability challenge is a matter of institutional relations, rather than a matter of technology for planning: relations must become more horizontal and based at all on methods and procedures for cooperation between local authorities and consultation/participation of public and private stakeholders.

2.1_The planning process governance

It should be noted that the innovative transition from urban planning to local governance is intimately connected with a multi-level system of shared knowledge and methods.When decision making and public deliberation processes are characterized by a multiplicity of public subjects with relevant and differentiated tasks, it is essential to practice the multi-level governance. The multi-level governance is of particular significance in the field of urban and territorial transformations because it deals with the uniqueness of the physical space and the natural interdependence between the various components of the environment (air, water, topsoil, subsoil, biotic communities, etc.) which characterize any human activity and conditions for its operability. Such environmental organic unity and integration contradicts the separation and segmentation of tasks and functions that characterize the administrative action.

Practicing multi-level governance means to implement actions, behaviors and attitudes that favor a process of decision-making avoiding the deliberations of authority, which in turns, imply that decision makers, primarily public, may, as a consequence, don't adopt attitudes that determine the block of each operability.

In the italian public administration, still persist a hierarchical top-down approach, where public subjects express their own formal “veto power” to “influence” local policy. The over simplification of the power expression over municipalities by sovra-local public authority isn’t able to guarantee the effective success of the initiatives, because the complexity of the relationships among different competences and knowledges, require better capacities of co-planning between the involved subjects rather that a vertical approach.
It is therefore necessary that public administrations, at all levels – and private operators too – assume attitudes to co-work together for achieving sustainability, practicing the Co-planning attitude for the territorial government, through the instrument of the Co-planning Conference.
The Co-planning Conference favors feedbacks among different stakeholders positions, offering the opportunity to share communicable targets. However, the creation of a common agreement during decision making phase forces the involved subjects to declare what they really want, and the activities they have to pursuit.
The complexity of Co-planning Conferences is given both by the creation of a common decision making process based on a shared cognitive framework, and by the “formal” expression of power and competences of the subjects which are representatives of institutional bodies (Presidents of Region and Cittàmetropolitana di Torino, Mayors, or their delegates).
In this way, the public administration defines and declares the criteria by which it elaborates the evaluations: this corresponds to the so called “scoping phase” of SEA processes.

2.2_The challenge for LIFE SAM4CP: using ES to evaluate plan options

The complexity of governing urban, territorial and environmental phenomena through the plans require a great amount of analysis, interpretation and also graphic representation. Therefore these three activities are constitutive of the planning process.
LIFE SAM4CP project aims to demonstrate that territorial sustainable development requiresthe application of integrated skills – at all scales – of ecological, economic and socio-political disciplines within a transdisciplinary framework. Therefore, the ES analysis is one that require such integration between different evaluations, because the context based assessment of biophysical and economic valuesis based on integration between theories of environmental economy, geographic information system, mapping and representation of territorial data.
ES assessment for planning purposes is one of the challenges that both academic and administrative sectors have to deal in the next years. Indeed, in areas where good quality of ecosystems is maintained, the territory and its local community became more resilient and less vulnerable (EEA, 2010).
But the incorporation of ES assessment for planning purposesrequires radical re-thinking of the local governance system and in particular the planning activity for plans construction, as an instrument of knowledge both regulatory and strategic.
The role of the ES analysis should enforcethe integrated planning approach, especially joining the Strategic Environmental Assessmentthat produces

planning scenarios and a shared framework for evaluates, by public and private subjects operating at different levels and in different sectors, the spatial trade-offs among different land use functions. The role of ESassessment is to define the fixed and flexible elements of negotiations for land use regulation, therefore it represents the integration between plan and SEA which is essential to define broad strategies of sustainable development overcoming the pure technological enhancement of environmental issues.
Generally, the ES analysis helps institution and local stakeholders to play their choiceswithin a background strategy for sustainable development, which fixes the rules for improve or to restore theidentity characters of the territory. However, it doesn't have an adequate regulatory support in the planning process. For this reason one of the LIFE SAM4CP actions involvesthe realization of a structural variant for the local plan first in the municipality of Bruino and later in other three municipalities.
These variants pursues the goal of reducing land consumption and uses the co-planning procedure between Region, Cittàmetropolitana di Torino and the involved municipality, using ES assessment.
Thus, SAM4CP provides to involved municipalities (through a consensus building process), tools to support planning decisions and accompanies them in the revision of their urban plans.

2.2.1_Ecosystem services and co-planning

Among the activities of Co-planning, the relationships between public institutions andbetween institutions and users, are based on collaboration and participation in the definition of planning contents. In that phase, the involved institutions are forced to share the definition of the knowledge framework (which is complex and multileveled among different scales) and the objectives, methods and projects. Co-planning allows every institution to provides their information, knowledge, skills and specificities, in particular through its plans.
In Piemonte Region, the introduction of this new approach to urban planning dates back to the Regional Law n.1 of 2007 which was a partial modification of the regional planning law in force at time. Then it was confirmed by further partial modification introduced by the Regional Law n. 3 of 2013.
Co-planning is like defined a time-dependent path but open and constantly updated: the local administration share its knowledge and compares the diagnosis with other institutions and stakeholders, seeking incrementally an agreement on the general objectives and guidelines to pursue.
The innovative aspect is that the Conference is convened and chaired by the Mayor of the Municipality that propose the structural urban planning variant. During the Conference such Municipality take part, with voting rights, with the Città metropolitana di Torino and the Region.
A crucial aspect is that, depending on the contents of the structural variant, the mayor of the Municipality may invite at the Conference – without voting rights – other entities or authorities and stakeholders, competent or simply interested in territorial planning.Obviously, behind the decision to invite other actors, there is a political assessment by the Mayor whichselect only those that seems useful to involve. The deliberations of the Conference are valid when shared by the majority of participants with voting rights and the

conclusion of the planning process takes place in the town council, on the base of the Conference results.
The Municipalities that have joined LIFE SAM4CP, including the case of study of Bruino, will take part to the Co-planning Conference with the analysis on ESdeveloped during the project. Such analytical frameworkis developed prior to the final definition of the contents of the plan and commonly with the Strategic Environmental Assessment.

3_Ecosystem Services assessment

The above mentioned Conference, which is the pillar of Co-planning approach, is a crucial aspect for achieving the target of SAM4CP project. It is in such Conference that the scientific knowledge of ES, the agreement between stakeholders, and the participatory approach with local community, are discussed together among different administrative levels to find the decisional agreement.
Such agreement is the keystone of project aim: the uses of ES as a proxy for a sustainable development generates abetter planning activity. By the way SAM4CP consider the uses of new ESmapping techniques as a central part of a common knowledge system for governing land use change effects.
The construction of ES values in the case of study has been reached using the software InVEST-Integrated Valuation of Ecosystem Services and Tradeoffs. The software may be useful for informing resource management strategies and quantitative ranking of scenarios that can aid decision making, also because is a powerful tool to explore possible results of scenario between different land use alternatives.
The softwarewas usedto estimate the 7 main ecological functions provided by natural soil (biodiversity, carbon sequestration, water purification, water yield, contrast to soil erosion, provision of habitat for pollinators; food production). Models were builds to have a great deal of accuracy and precision in order to support the management of a planning project with local community: the challenge was not to use InVEST as a tool for accountability of ES, but to use it as a real support in decision making mechanism during the Co-planning phase.The research presented considers the last release available (in 2015) of the InVEST model (version 3.1.0).

3.1_The biophysical evaluation of ES

The need of reliable, precise and accessiblegeographic datasets is increasing, and the request of such data is only partially fitting with the provision of public geospatial datasets (Benini, et al., 2010). This is forcing techniciansto create “ancillary” datasets which are site specific and reliable, but not comparable between similar methodologies.
The organization of the input was crucial for output reliability, especially for those functions that requireda huge amount of data to connect with LULC map. As regard as input collection for InVEST, some limitations weredeterminedby the common dataset offered by the standard models of the software. Normally such modelsare too general, because environmental data (climatic, hydrologic, agronomic) are collected and restituted at macroscale rather than at microscale. For these reasonsit has beendecided to:

- collecthigh detailed environmental data using the web GIS online dataset of the Piemonte Region;
- useInVEST as a tool to support environmental analysis which was refined, articulate, handled with adjustment, even simplified, with adding information, or with a synthesis of results made with subsequent multilayered analysis (Keller, et al., 2015).

Even tested, the experience with the program is so limited. Thereforeit is quite problematic to understand at how changing parameters of each single variables can have significant effect on model's output. Anyway, further advancement of the project will fill such gaps.

3.1.1_Mapping ES using Bruino (TO) as a case of study

The Municipality of Bruino(among other three Municipalities) has been selectedas a key case study in LIFE activities according to the letter of interest. The LIFE activity has to produce avariance of the Local Land Use Plan.

The phase 1 of the project has been dedicated to run the software InVESTfor each ES selected. In particular, actions were dedicated to:

- the construction dataset (using standard and ancillary data);
- the research of sources for input software values;
- the interpretation of output models.

Immediately a question arises from actions development: the necessity of achieve a betterintegration onLand Usedata (repertories as CorineLand Cover) with Land Cover ones (imperviousness of soil). Actually "artificial surfaces"are simply considered,by environmental analysis,as a uniquecategory of "bed values" which generates noise and pollution; while, on theother hand, artificial green areasare a consistent and connective part of primary rural ecological network. A green garden, placed inthe dense city, even private and inaccessible for public uses, can provide ES as a natural widezone. Certainly, if a green zone has artificial boundaries, the habitat quality of some species is neglected; despite this, all other relevant functions are still provided by such open space.

The degree of impervious surfacehas been measuredas the average value for each Land Use class ofBruino, exporting the attribute table of LULC shapefile and creating a pivot table using Microsoft Excel. Such value has been used only for quantify the permeability of artificial surfaces, thusthe index of permeability has been used asanadditionalqualitative indicatorto settle the software'sinput value for environmental quality function.

Than the software was launched for all the main ecological function below described.

Habitat Quality: the map shows the cluster where the quality of habitat (as proxy ofthe overall environmental quality) is high or low. The case shows that on the north east (the Sangona River) and south west (the hill) of the municipality are placed the main "corridors". In the middle of the flat floor of the valley the settlement system is distributed, but leapfrogged clusters of medium environmental quality are spread even close to dense residential and industrial zones.

Carbon Sequestration: the model uses data on wood harvest rates, harvested product degradation rates, and stocks in carbon pools to estimate the amount of carbon currently stored in a landscape or the amount of carbon sequestered over time. The map shows were soils are capable to "hold" a high degree of carbon, and provide a "carbon pool" function which is fundamental also for climate change mitigation policy.

Water Yield: the map represent the relative contributions of each land use cell to the yield of water per each watershed. The value ofevapotranspiration has been used to map those areas that better filter the stream via evapotranspiration.

Nutrient Retention: the map indicates the contribution of vegetation and soil to purifying water through the removal of nutrient pollutants from runoff. In particular the map shows at pixel level how much load from each pixel eventually reaches the stream.

Sediment Retention: the map indicates the total potential soil loss per pixel in the original land cover. High values correspond to places where loss ofsediment is higher than in other parts. This vulnerability is crucial especially for territories where erosivity is high (hills or mountains).

Pollinator Abundance: The map represents an index of the likely abundance of pollinator species nesting on each cell in the landscape. It provides information on sites where suitability for nesting is high or low, this give adequate information especially for planning agricultural uses.

Crop Production: this services has been mapped using the Land Capability Classification modelprovided by the Regional database of Soil, and not InVEST. This inventory was sufficiently accurate to estimate which was the productive capacity of each pixel of land, according with the definition of suitability of soil for agricultural purposes.

3.2_The economic evaluation of ES

To assign an economic value to specificES provides the possibility to develop better environmentalplanning practices and toincrease the knowledge of the stakeholders and decision makerstowards the economic values of natural, non-reproducible, resources.

A pioneer study of Costanza et al. (1997) classified the global land use into 16 primary categories and grouped ES into 17 type; using this approach it waspossible to extract equivalent ES weight factor per hectare in different areas. The total ES of each land use category was obtained through multiplying the area of each land category by the value coefficient.

Related to this, when ES values is associated to a land use transition matrices, notable changes on ecosystem values can be observed and the economic loss of specific transitions can be noted and explained. New indicators (as the percent decrease of the total ES value) can enforce the evidence of economical long term effect of land use change and urbanization. Sometimes the rate of increase or decrease of a specific land use does not correspond to the rate of variation on ES. This is why it is so important to exactly quantify ES values.

Nevertheless, many economists criticized the valuation method because different approaches may produce significantly different results. Moreover, some studies have pointed out that the valuation method is less meaningful to estimate the total value of an ecosystem, and may be more appropriate for

[3] Project "Making Public Good Provision the Core Business of Nature 2000" (LIFE+11 ENV/IT/000168) coordinated by University Consortium (CURSA). For more information: http://www.cursa.it/ecms/uk/research/making_good_natura.

marginal change analysis (Shuying et al. 2011). So the ES analysis is useful to analyze the rate of increments or decrement of values rather than the total-value of a land use scenario (Bateman & al., 2013).

3.2.1_The methodology in Life SAM4CP: a multi-criteria approach for the economic evaluation

One of SAM4CPoutput is the estimation of economic values of soils on the base of their biophysical values.

Many authors discuss the possibility of reaching economic values ofES, but few of them explains how to link the biophysical side of evaluation with its economic value. Nevertheless,the project presents a first simulator of land use scenario, which keeps togetherspecific biophysical performance of land with a corresponding monetary value. Using the ES mapping as the base for biophysicalquantification, the challenge wasto adopt and found methodologies to associate parametric"prices" of ES provided by soil. A typical example isthe carbon sequestration service, which is the natural storing service offered by soil acting as carbon pool.

Starting from LIFE+MGN (Making Good Natura)[3] research models, the biophysical maps where used to associate economic values.

Firstly, it was assumed that all measured values are "potential" rather than "definitive",and they derived from market price of substitution/artificial production of asimilarservicewhich normally is provided by soil. The word "potential" is referred to the condition of arbitrariness of such quantification, and the challenge is to estimate the trend between one, or more, alternative land use scenarios. This approach gives the possibility to understand which is the trade-off among different "potential" function that soil can provide.

Biophysical evaluation produces output per pixel expressed by (i) indexes or (ii) absolute quantities. The seven functions defined by projectare estimated using such units:

- index from 0 to 1 for Habitat Quality and Crop Pollinator;
- tons/pixel for Carbon Sequestration and Sediment Retention; mm/pixel for Water Yield; kg/pixel for Nutrient Retention;
- values form 0 to 8 for Land Capability Classification (Crop Production).

While for ES with absolute values it is possible to definea price per unit (according with scientific study, 1 tons of sequestered carbon is equal to 120 euro), mistake arises when the economic value is associated to indexes. Such limitation is declared also by the huge bibliography whichremarks the impossibility to allocate a final price to ES (e.g. biodiversity).Anyway, even though with declared limitations, a "derived" value was applied, using the classical approach to economy of quantify the "production value" of a goodrather than its "willingness to pay" value.

An example is given by two important functions expressed with biophysical indexes: Habitat Quality (which measure the biodiversity value) and Crop Production (which measure the productivity capacity). The economic evaluation of biodiversity index was estimated from the price of "reproduction" of land uses that provides biodiversity in urban areas.For example the cost of planting a forest, rather thanthe cost of a public garden for urban green areas. This price of "substitution" (how does it cost to reproduce such goods?)

was distributedusing a linear function to all the land use categories. The same approach was used for potential productivity of soil. Starting from the market values (per hectares) of specific cultivation it waspossible to estimate which wasthe average economic value per hectare of agricultural landscape on-specific sites. Thus the "potential" agriculture productivity for each land use class was calculated using a linear equation.

The relationship between the biophysical and economicmodels of evaluation allows,at the time of land use changes (potential or defined), toget a continuous variation between values both environmental and socio-economic, and estimates the overall impacts led by the potential transformation of land use.

4_Conclusions

SAM4CP is one of the EU project which is aimed by pragmatism in the use of new concepts as ES for sustainable territorial government. The project tries to introduce new procedures and technologies among stakeholders to achieve a better land use planning for local communities. By the way, its applications in research is dependent to the local planning needs with a detailed, abundant, system of knowledge and, moreover, to use the great theoretical amount of information related on ES for planning purposes, considering all the typical problems of planning activity (e.g. assigned building rights, constrains, incongruence between planned and existent land uses).

Procedural and technical innovations were discussed in the paper and both are characterized by uncertainties and limitations. Even if Co-planning Conference is traditionally embedded by planning culture of Piemonte because it has been introduced by Regional Laws since 2007, the way in which public authorities express their opinion often continues to be characterized by a hierarchical attitude, particularly from the Region, instead of consider-local needs and knowledge. The Co-planning Conference should be used as a place to determine goals, plans and actions through shared, horizontal and collaborative activities of public authorities at all levels.

Secondly, a high degree of uncertainty arises for ES assessment when variable's input is discussed. And such uncertainty doesn't enforce the position on local Administration among Co-planning Conference. Thus it is soon to understand if SAM4CP project can really reach the possibility to "increase the power" of the Municipalities using a defined scientific approach to valuate different land use scenario.

The risk is to be much oriented on a pure theoretical advancement of research on ES rather than to be operative for introducing real planning innovation over the traditional framework of systems and powers.

Anyway, the consensus building approach based on a deep knowledge of ES trends and dynamics is shading lights on some planning issues related to sustainability of land uses: only a qualitative knowledge, rather than quantitative, supports practices of mitigations or compensations for urbanization. It is widely demonstrated that there is not a direct relation between the quantity of urbanized land and its quality.

If the prior strategy at EU level for 2050 is to reduce (limitation) the amount of land take, it is equally important understand how to manage next transformations of land using mitigation and compensation measures. Far away from being the most important target of the project, if this simple concept is agreed by sovra-local authorities than a better predisposition to share a common system of knowledge on sustainable land uses will be reached.

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TAILORING THE NEXT GENERATION ENERGY MANAGEMENT TOOL FOR SMART CITIES

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Abstract

In this position paper we propose a next generation eNeRGy management solution for smart cities based on the Internet of Things- IoT NRG Manager, to efficiently manage the energy locally produced and consumed. IoT NRG Manager is interoperable with the Internet of Things, it provides an Open Data API that allows third parties to access to energy related data. The privacy issues are addressed by a combinatorial approach of Privacy and Transparency Enhancing Technologies.

The IoT NRG Manager is built up by (i) a smart decision support system that measures, predicts and balances energy production, demand and storage and (ii) a Virtual Power Plant (VPP). In the context of this work the VPP is a high level design tool based upon load aggregation of near real-time metered energy demand and generation data at building/apartment levels. Selected data is aggregated up to city level, or user defined and selected levels such as district, neighbourhood, low voltage electricity network, district heating network etc. The VPP also facilitates the option to model 'what-if' scenarios through simulation of additional distributed energy resources (DER), electricity storage, electric vehicles etc. at tool defined building and/or city/district level.

On top of that are developed user-friendly web portals and functions that inspire new business models for all stakeholders (consumers, prosumers, city authorities, energy service providers, TELCOs, ESCOs, etc.).

Our tool is currently being deployed in two European cities: Plovdiv – the second largest cities in Bulgaria, and Rijeka – the second largest city in Croatia.

1_Introduction

Today, roughly half of the world's population lives in urban areas, consuming two-thirds of total primary energy and generating over 70% of global energy-related CO_2 emissions. By 2030 it is estimated that around 60% of the world's projected 8.2 billion people will be housed in cities and towns. This means that residents who live and work within a city will consume around 75% of the world's annual energy demand. If most of this demand continues to be met by fossil fuels, then cities and towns maintaining a business-as-usual approach will experience large increases in CO_2 emissions, greatly endangering the health of citizens and surrounding ecosystems. Fortunately, goals set by the European Commission state that by 2020, 50% of Europe's electricity networks should operate on 'smart' principles. The European Union (EU) target is that by 2020, at least 30-35% of electricity consumption is covered by Renewable Energy Sources (RES), compared to a 16% share recorded in 2006 (1).

Many EU cities are setting examples to follow in their quest to become energy independent, such as the Swedish city of Växjö, which meets over 54% of its energy demand with local renewable energy, city of Freiburg with 10% of electricity coming from renewables or the Spanish island el Hierro with 86% of its consumption coming from renewables aiming a 100% in the next years (2). Therefore, local generation and the inclusion of new actors such as prosumers are key to achieve the energy efficiency targets for the next years.

In order to provide these benefits and meet EU targets, the smart grid must be able to seamlessly integrate various existing and/or new technologies – meters, sensors, data processing systems, etc. – with the physical infrastructure required to generate, transmit and distribute electric power (2). Utilities and city authorities have long been using network systems such as SCADA to optimize resources and monitor assets to carry out preventative maintenance. However, the rich data sets generated and stored in these "silo" systems are found in a variety of formats and are not easily accessed by third parties, thus preventing the optimal management, control and efficiency of many city services (i.e. utilities, security, health, transportation, street lighting and local government administration).

On the other hand, today's urban environments offer near-100% internet coverage and are equipped with pervasive sensors and a wide range of embedded and mobile devices (i.e. smartphones, smart vehicles, equipment sensors, air quality sensors, etc.) that generate significant amounts of data, in what is called the Internet of Things (IoT). Therefore, the fast grow of the IoT, which is integrating and unifying all the communication systems in a Smart City, and the continuous deployment of smart meters in public and residential buildings are opening up new approaches for the energy management in cities, strategies to incentivise the local generation and better tools to achieve energy savings and Green House Gas (GHG) emissions reductions.

To efficiently manage energy resources in cities, in this paper we propose an eNeRGy management solution based on IoT for smart cities: IoT NRG Manager, which is built-up by a *Smart City Database* (SCDB) and a *smart Decision Support System* (smartDSS) divided in two-level decision approach:

- *Local Decision Support System* (LDSS). It engages consumers and prosumers by capturing near real-time data related to their energy consumption, as well as energy production from their installed Distributed Energy Resources (DER), displaying it on a user-friendly interface via smart phones, tablets, PCs, etc., and provides support for decision making.
- *Centralized Decision Support System* (CDSS). It aggregates data from all LDSSs to provide city-level decision support to authorities and energy service providers. The CDSS generates a number of parameters, including city-wide energy production and consumption forecasts.

The security and privacy aspects are a major problem that must be addressed in any IoT solution. For the security aspect, IoT NRG Manager provides means of communication and end-points (web services) to ensure that the communication channel between utility's AMI and SCDB is encrypted. This schema also applies for the inter communication between the high levels components (LDSS, CDSS and VPP). Regarding the privacy, it is addressed by a combinatorial approach of Privacy and Transparency Enhancing Technologies. More details are presented in section V.

Moreover a real deployment of the IoT NRG Manager is planned for 2015 in two European cities, in concrete, the second biggest city in Bulgaria, Plovdiv and also the second in Croatia, Rijeka. With more than 1000 new smart meters installed in the pilots, IoT NRG Manager provides functionalities to different actors in the energy domain.

In Section 2 we outline the main components of our energy management tool. In section 3-4 the logic architecture of the SCDB, smartDSS, CDSS and LDSS is depicted and the communications between components are explained. In section 5 we propose a security and privacy approach for the tool. In section 6 the magnitude of the pilots were the IoT NRG Manager will be validated and evaluated is described. Finally in section 7 we summarize our approach and propose directions for future work.

2_Smart City Energy Management Based On IoT

In Figure 1 is shown a draft architecture of the components present in the IoT NRG Manager. The SCDB is where all the information regarding energy measures, building parameters and additional information (weather, energy prices, etc.) is stored. Interfaces and APIs provide all the necessary information for the smartDSS modules.

The *Automatic Metering Infrastructure* (AMI) of Rijeka and Plovdiv, communicates via utility interface with the SCDB. The smartDSS communicates in a bidirectional way with the SCDB. The Open Data API (OD API), gives access to information regarding consumptions of the pilot buildings, as well as, other information such as production with renewable energies and CO_2 emissions in the city. The end-user or municipality (for public buildings) are the owners of the data generated and therefore they are responsible to allow or not the usage of their data in the OD API.

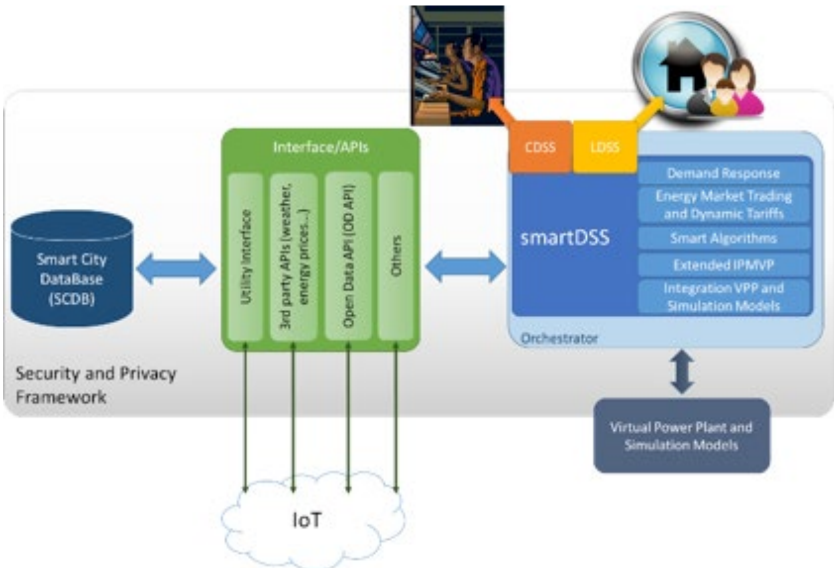

Figure 1. IoT NRG Manager components.

The Orchestrator is responsible to ensemble and orchestrate the communications between the smartDSS and its different modules:

1. Smart Algorithms: Electricity, Water, Gas and Heating forecasting algorithms.
2. Energy Market Trading: Generation of the variable energy tariffs that allows dynamic prices of energy in the city and trading strategies of prosumers.
3. Virtual Power Plant (VPP): High level design tool based upon load aggregation of near real-time metered energy demand and generation data at building / apartment level. It allows also the creation of 'what-if' scenarios. (For more information see section IV – C).

Finally the CDSS and LDSS are the interfaces with the end-users; the CDSS for the Utility and Municipality of the city and the LDSS for the end-users, both private (citizens) and public customers.

3_SCDB

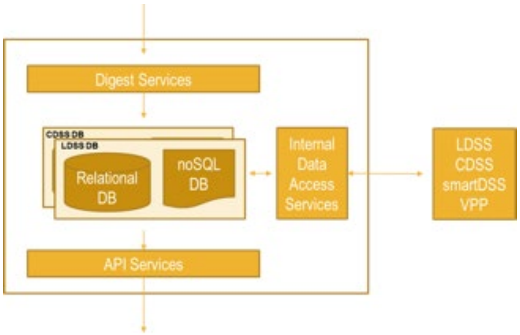

Figure 2. SCDB logic view.

The SCDB is depicted in Figure 2. It contains the database of IoT NRG Manager, and provides components to import data from external sources, as depicted in Figure. 1, and additionally provides interfaces for accessing energy related data collected from the main modules of the IoT NRG Manager (LDSS, CDSS, smartDSS and VPP). There is a special module, which allows access to data externally following the privacy and security policy of the IoT NRG Manager (See section V).
The database is divided in two main blocks, which matches the functionalities target for the LDSS and CDSS. Basically, all energy related information from meter up to building level is stored in the LDSS database, while all energy related information above building level is stored in the CDSS database, this include aggregated meter at city level (district wise and city wise) data and VPP data.
Booth LDSS and CDSS incorporates a relational database, where the relation of the smart meters is defined (apartment/home/business, building, district and city level) and a noSQL database to store massive energy information.

3.1_Open Data API services

Figure 3. OPEN API module.

The API service component is responsible to grant access to the energy information collected and computed within IoT NRG Manager following the security and privacy policy. It provides an open API that allows 3rd parties to offer external services to the users of the platform. This component provides a set of different modules as shown in Figure 3.
The Open Data API is a tool that developers will use create the solutions that citizens and other stakeholders want.

Component	Description
Energy Data	This component exposes the energy data stored in SCDB. Provides access to current and historical data, from meter level up to city level.
User Data	This component provides information from users following the privacy policy
Access Control	This module controls which information can be access through the open API based on the request and the type of external service accessing the data. It logs all the request and all data access from external services.
Privacy Policy	This module is used to set privacy policies for data access

4_IoT Decision Support System Engine

4.1_smartDSS

smartDSS is the acronym of "Smart Decision Support System", which is a concrete solution comprised of: 1) a tool to measure, predict and balance energy production, demand and storage; 2) a tool to measure and verify reductions in energy consumption and GHG Emissions resulting from city energy use; and 3) user-friendly web portals and functions that will inspire new business models for all stakeholders (consumers, prosumers, city authorities, energy service providers, telecommunication companies, ESCOs, etc.). The Decision Support System leverages the cities' intelligent electrical and thermal grids to empower all of the actors involved and enable optimal distribution and trading of decentralized renewable energies production in a city, as well as the integration of Combined Heat and Power (CHP) plants connected to the smart district heating and cooling grid.

4.2_CDSS

The CDSS (Centralized Decision Support System) Component of the proposed platform is responsible to aggregate and manage data at city and district level. That Component deliver a set of functions to end-users as Authorities, Energy Provider Services, ESCO, Municipalities, collecting data that comes from other components of the system. Moreover, the CDSS provides an interface specialized for the user typologies. Thus, each user accesses only to the tools useful to perform its activities. For instance, it can be considered the different approach in the data management of an Analyst and a Decision Maker. The aim of CDSS is to integrate measurements data, business model, simulation data and forecasting data in a view that allows the user to manage the different aspects with a unique tool. This, enables the forecast and planning renewable power generation available in the city, a real-time optimization and scalability (meaning its ability to be enlarged to accommodate that growth of data).

The CDSS allows the following activities:

- Get a continuous snapshot of city energy consumption and production
- Manage energy consumption and production data
- Forecasting of energy consumption data
- Planning of new energy "producers" for the future needs of the city
- Visualize, analyse and take decisions about the information provided by all the connected end points that are consuming or producing energy.

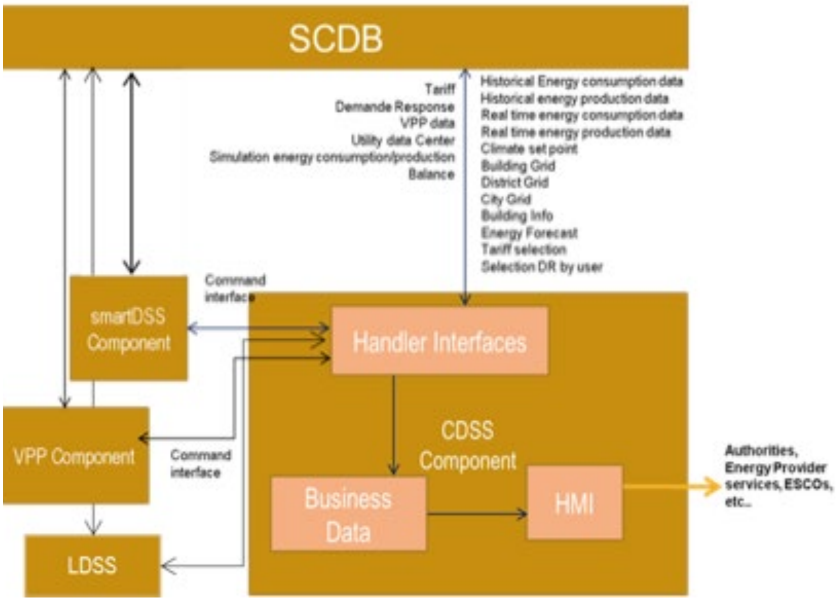

Figure 4. CDSS Architecture schema.

As it is shown in Figure 4, it is composed by a back-end and front-end. In this task the HMI or Graphical User Interface (GUI) for CDSS is developed with a novel framework employing web technologies (HTML5, CSS3, JScript, Websocket) to provide a web 3.0 user interface. The CDSS provides the communication between VPP, smartDSS and LDSS and this makes it fundamental for the orchestration of the activities.
Moreover it provides functionalities to aggregate data in order to create the demand curves that can be used to analyse possible peaks and produce offers. Other important features of the CDSS are:

- Dynamic tariffs support
- Offers Demand/Response flow
- Forecasting data management
- Near real time data visualization
- Technical losses management
- Historical data visualization

It works in strict collaboration with the VPP component that is responsible to aggregate data at city and district level. This aggregation of data is the base to produce simulation, forecast and near real time data. Another important aspect to highlight about the CDSS is the connection with the LDSS. This functionality allows to prepare dynamic tariffs and stimulate an engagement behaviour with the consumers. The CDSS moreover communicates with the smartDSS component in order to activate the forecast processes. The forecasting data are stored into SCDB where the CDSS takes the values. Thus, that approach produces many benefits, in fact the consumer can have reduced energy consumption and costs and, most important, can acquire a more conscious behaviour versus the environment.

4.3_Virtual Power Plant: A High Level Design Tool

VPP stands for Virtual Power Plant. Within current literature the term VPP has no firm definition (3)(4). The VPP in the context of this work is a high level design tool based upon load aggregation of near real-time metered energy demand and generation data at building/apartment levels. Selected data is aggregated up to city level, or user defined and selected levels such as district, neighbourhood, low voltage electricity network, district heating network etc. Figure 5 illustrates the communication workflow between the VPP, CDSS and SCDB (both discussed above). The VPP is to act as the background calculation engine to the CDSS, where the CDSS is to act as an interface to the VPP initiating user commands to the VPP such as grouping schemes, what-if simulations etc. The SCDB acts as an intermediate between the VPP and CDSS; access to common data and storage of VPP computed data.
The VPP also facilitates the option to model ‘what-if’ scenarios through simulation of additional distributed energy resources (DER), electricity storage, electric vehicles etc. at tool defined building and/or city/district level. This feature is in addition to load aggregation of near real-time metered energy demand and generation data at building/apartment levels within the VPP. What-if scenarios use historical building and meteorological metered data stored on the SCDB as a driver for simulating results, rather than forecasting ahead in time.

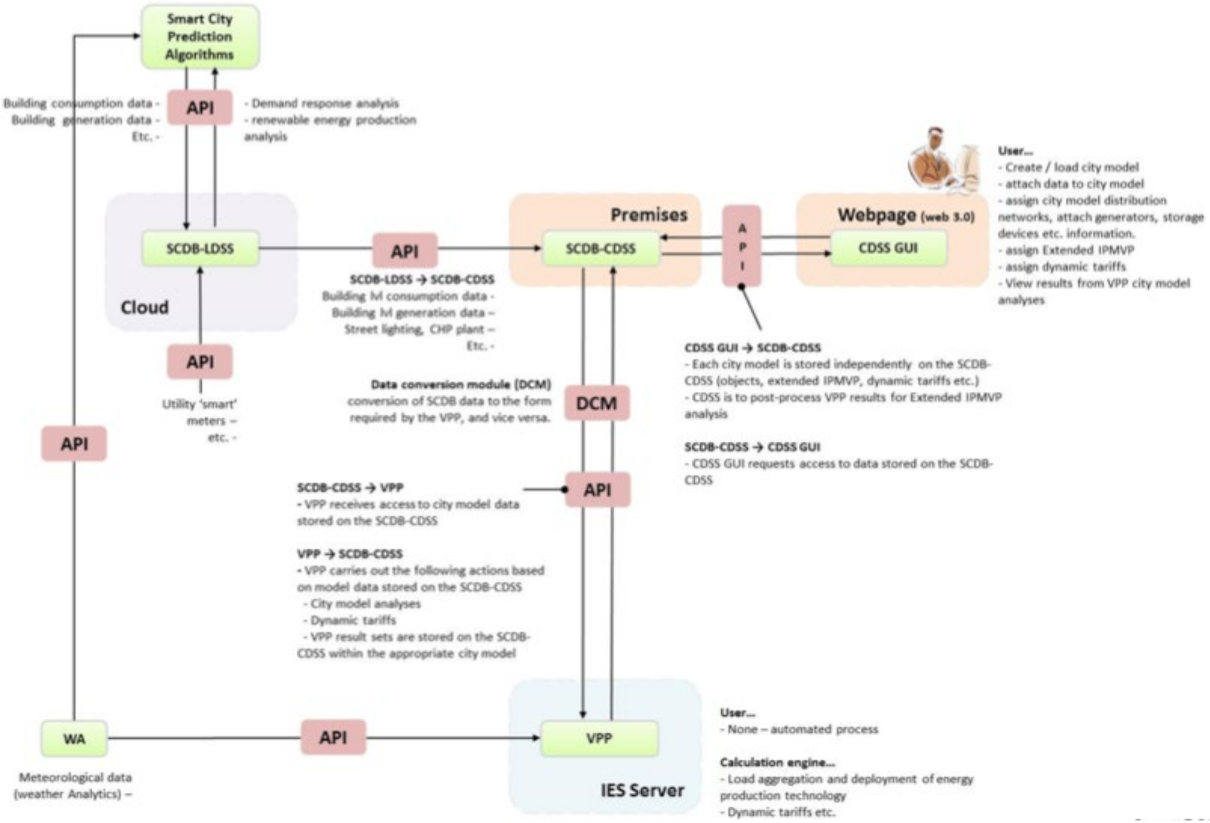

Figure 5. VPP communication workflow diagram.

An example of a what-if scenario is the simulation of photovoltaic (PV) panels at building level. The what-if simulations are directed towards providing feedback to the user on the following type of question: *If I installed 'x' renewable or low to zero carbon (LZC) technology to one or many buildings within a district, how much traditional energy in the sense could have been offset by installation of such technology?* The user can analyse this information within the CDSS and opt to carry-out further what-if simulations.

Target users, city planners and utility companies, will be able to use the tool to gain an understanding of energy demand/generation at user defined and selected levels of interest ranging from high level city planning to the selection of individual buildings or user defined energy networks and so on. 'What-if' scenarios aid in future development and planning of cities.

4.4_LDSS

LDSS stands for Local Decision Support System. LDSS main goal is to engage consumers and prosumers on the efficient use of energy. The engagement is based on data, captured in near real-time, related to their energy consumption, as well as energy production from their installed Distributed Energy Resources (DER). The engagement is target throughout a user-friendly interface using every-day-use devices; smart phones, tablets and PCs.

Simplified interfaces show users energy usage, as well as energy produced. Comparison with previous periods, as well as other consumers/prosumers, in combination with recommendations on the optimal use of energy is expected to engage end users on the management of "their" energy.

Additionally, LDSS provides support for decision making, for instance, it advises how to achieve a demand response actions, which dynamic tariff is

[1] enControl™ platform is commercial property of Sensing & Control S.L. It is designed to allow agile management of data in the energy efficiency, security and automation fields: http://www.sensingcontrol.com.

more convenient and the relation with other environment parameters (like weather) affects the user consumption & comfort.

Users' comfort is guaranteed with the Smart Heating system of the LDSS. It provides to end users a tool, to modify at any time the target temperature of their homes. The control is composed by a main thermostat and individual thermostats. While the main thermostat is a logic device, each individual thermostat matches a physical one located at home.

KPIs for users' behaviour and satisfaction with the LDSS are also considered. The measured data is collected for **each user separately** on **hourly** basis. Some of the KPIs considered are: active users/month, logins/month/user, how long people stay being logged, features (clicks)/month, advices page clicks/month – this is quite interesting as we have seen that some users only check advices, usually woman, and not checking consumption profiles, etc.

LDSS is the link between the energy provider and the end user, which is meant to be the tool for customer loyalty.

5_Security and Privacy

5.1_Security

Figure 6 shows the main building blocks of the data flow chain in the IoT NRG Manager; (i) the smart grid, (ii) the end user and (iii) the backend-frontend service of the IoT NRG Manager. The block (i) is out of the scope of the IoT NRG Manager. The utility is applying industry standard technologies to ensure that the data they are managing can be trusted. At this level, IoT NRG Manager provides means of communication and end-points (web services) to ensure that the communication channel is encrypted. This is done using industry standard technologies based on TCP/IP with Secured SSL protocol or REST over HTTPS and Root Certificates X.509 v3. As IoT NRG Manager platform follows a SOA (service oriented) architecture, this schema also applies for the inter communication between the high levels components (LDSS, CDSS and VPP). The LDSS and the SCDB are developed on top of enControl™ platform[1], which provides a base API for the exploitation of the upload/download of metering and sensor data, including data aggregation and fusion capabilities. IoT NRG Manager provides services to its users through graphical user interfaces built on web technologies and native smartphone apps. Any component accessing to the IoT NRG Manager uses the API, exposed in

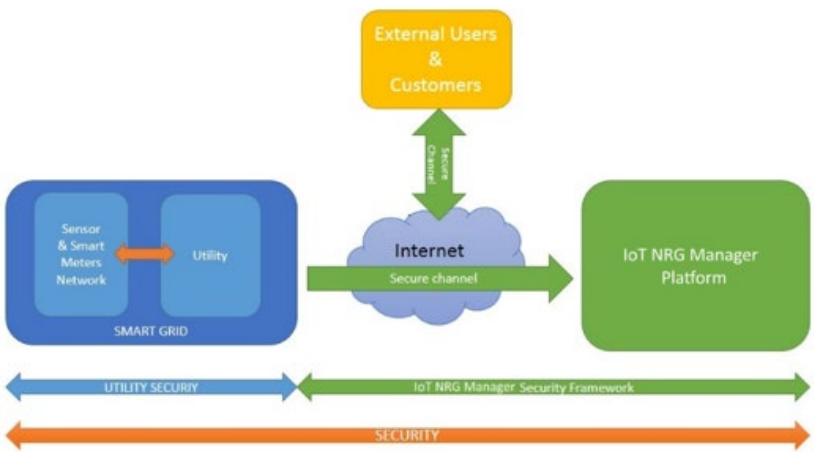

Figure 6. High level diagram of the security structure.

REST form over HTPPS, and only accessible after authentication. It is worthy to comment that the different functions of the API are accessible depending on the type of user assigned.

5.2_Privacy

Privacy is different from security. Privacy does not allow trust, while security at least allows trust in the exchange of keys. "Access control" is a metaphor used by both security and privacy. As a consequence authentication is the only source for protecting private data. In the early 90ties, data minimization at authentication time was the means to protect privacy (5). This authentication time data minimization generated a set of successful mechanisms, whose most well-known example are digital signatures, Public key Infrastructures, and identity management (6). In its most extreme case, anonymization (7) totally omits data for authentication. All these mechanisms are called Privacy Enhancing Technologies (PET). The usage of these mechanisms is limited due to the unwanted impact on the usage of data for management, e.g. usage of energy in smart grids. Other reasons range from cumbersome and hard-to use mechanisms to lack of trust.

Trust in smart grids requires to balance billing, where authentication is needed, with deduction of consumption patterns, where authentication is not needed to for inferences. The key requirement for the IoT NRG Manager is that direct access of smart meters by suppliers is not a useful way to preserve privacy, and that statistical data are sufficient to accomplish both privacy and management of energy usage. In 2004 Park and Sandhu's specification of usage control (UC) model approached this divergent interests (8). While, however, UC is an appealing concept from privacy protection view but it also has increased resource demands due to the permanent monitoring of involved data. While UC is limited to centralized systems, distributed usage control applies the concept on decentralized systems. Though, the performance issues increase in DUC. The most recent extension and direction in privacy is a total openness or transparency, where dashboards execute both monitoring and auditing. The family of mechanisms maybe called Transparency enhancing technology (TET).

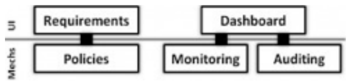

Figure 7. Transparency Topics.

We propose to follow a combinatorial approach of TET and PET. On the one hand users obtain information how their data and for what it is used. A dashboard provides a choice and consent option for users. Though, energy related data from the IoT NRG Manager platform is needed by third parties like energy utilities or innovative energy efficiency services. To prevent performance issues of DUC coming along with TET on decentralized systems, PET are applied.

Energy related Data is stored in the SCDB providing statistical data to requesting entities. The only meaning for Third Parties to obtain those data is via the Privacy Proxy (PrP). PrP checks if the request is valid according to the IoT NRG Manager privacy principles which is basically to hide the usage of a single household within an anonymity set. At present, IoT NRG Manager experiments with differential privacy, where in theory privacy can be broken by the number of queries addressed to the database. The fundamental idea of differential privacy is to guarantee that in the worst case not more than a

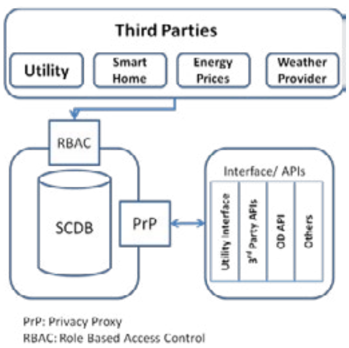

Figure 8. Privacy Protected Data Access.

predefined amount of information about a single customer can be obtained per request. One option to obtain this guarantee is to add Laplace noise based upon the global sensitivity of the request and a differential privacy parameter.

6_From Design To Reality: Deployment in Plovdiv and Rijeka

A principle objective of the IoT NRG Manager is to demonstrate the components proposed in two real-life European Cities with respect technological reliability, potentiality to participate in real energy markets, impact in terms of user engagement, feasibility of business models and energy and GHG emissions reduction. A substantial validation phase of more than 12 months is planned to enable enough data collection and tune the smartDSS and its components, as well as a solid evaluation of more than 6 months.

Plovdiv is the second-largest city in Bulgaria after the capital Sofia with a population of approximately 340.000 inhabitants. It is an important economic, transport, cultural and educational centre. It is the tenth-largest city in the Balkans, being a city with high population. The city of Plovdiv is represented by 29 buildings, including, one CHP Plant, two office buildings (prosumers), seven kindergartens (prosumers), one high school, one mayoral building, and 18 private residential buildings. They are representative of the city consumption and production profile. Additionally, the historical data from the distant meters and manually monitored meters will be integrated into the SCDB so that an excellent picture of energy consumption is built.

The CHP provides heat for the city, smart cool, and electricity for its own use. The two office buildings have PV panels installed and will act as prosumers, along with the kindergartens. The mayoralty building is the first smart cool user in the city of Plovdiv, and will also have smart electricity and heat meters installed.

On the other hand, with a population of approximately 144,000, City of Rijeka is the second largest city in Croatia. It is one of the first European cities that joined the European initiative "The Covenant of Mayors" in 2009 which connects cities with goals to exchange experience in implementing effective measures to achieve sustainable development through reduction of greenhouse gas emissions, increasing the use of renewable energy and energy efficiency. Rijeka has signed the Green Digital Charter committing to use ICT as a main driver to improve energy efficiency

Rijeka it is represented by 28 buildings, including several public buildings such as sports centre, the National Theatre, 5 primary schools and 2 kindergartens, as well as 3 residential. The deployment also includes the heating distribution plants within the city and the public lighting.

7_Summary and Outlook

In summary, instead of typical isolated energy management software incapable of reciprocal operation with other systems, IoT NRG Manager is able to take the most profit from the expansion of the internet of things, with the aim to improve the energy efficiency in cities. With our proposed solution, we build-up an infrastructure that makes possible the integration of various sources of data and makes them accessible to the end-users through two different GUIs - LDSS and CDSS, and also to third parties by means of an Open Data API, which is accessible only via the Privacy Proxy (PrP). PrP checks if the request is valid according to the IoT NRG Manager Privacy principles which is basically to hide the usage of a single household within an anonymity set.

Energy data flow from the utilities smart grid to the smart city data base have been successfully achieved, LDSS users are being timely informed about their current and predicted energy consumption, there are about 150+ LDSS active users in the platform. Besides a smart home application has been released, users in Plovdiv are using web based interface due to the low penetration of smart phones for the house holds users collaborating with the project. On the other hand, eight full equipped smart home installations were successfully deployed in Rijeka, where the local utility has conducted a series of demand response actions using the smart heating capabilities of the smart home solution. Rewarding schemas were defined to engage LDSS users to actively interact with demand response actions issued.

Partners within the iURBAN project are discussing how to make the tools available after the project termination as a singular solution. While the discussion is still ongoing and waiting for the validation of the results, the roadmap for some of the subcomponents (SmartDSS, CDSS, LDSS, VPP) have been defined. For instance, LDSS is available as a white label solution for service providers willing to explore and create new added value services around energy consumption/production, energy efficiency engagement, customer loyalty. Further information about the commercial service can be found at sensing & control home page.

8_Acknowledgment

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SUSTAINABLE NEIGHBORHOOD REGENERATION: HOLISTIC DECISION SUPPORT METHODOLOGY SUPPORTED BY A SOFTWARE TOOL

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neighborhood

Abstract

The traditional approach to energy efficiency in building retrofitting brings poor results in terms of urban sustainability, resource efficiency and economic return. In order to fulfill the EU-targets for 2030 and 2050 and to support the necessary building-retrofit market, the European project FASUDIR was established under the framework of a FP7 R&D program. FASUDIR provides an Integrated Decision Support Tool based on a new methodology supported by a software tool that will help decision makers to select the most suitable energy retrofitting strategy to increase the sustainability (economic, social and environmental) of a whole urban district. The Decision Support Methodology developed in FASUDIR guides planners of neighborhood retrofitting projects in a structured way through several phases of the project. The Methodology starts with the preparation phase comprised of data collection and data entry. The diagnosis phase demonstrates planners and stakeholders the current state of the neighborhood in terms of sustainability and overall energy efficiency. The decision-making phase helps planners to create optimized energy retrofitting variants for the neighborhood. It allows considering the neighborhood as a global energy system by assessing heat and electricity related synergies and interactions between buildings. Based on the results the planners are able to design heat networks and to plan the inclusion of renewable energy sources taking into account smart grids and energy storages. The created energy variants can be assessed and ranked with regard to their sustainability by a MCDA approach and the use of several simulated Key Performance Indicators (LCA, cost, energy, social aspects).

1_Summary

The European building sector is responsible for 40% of overall energy consumption sector and over 50% of all materials extracted from earth are transformed into construction materials and products [1]. With more than 70% of the building stock built before the first energy crisis (1970's), energy retrofitting of buildings is envisaged as the most promising strategy to reach the EU's "40-27-27" targets. The traditional approach to energy efficiency in building retrofitting brings poor results in terms of urban sustainability, resource efficiency and economic return. In order to fulfill the EU-targets for 2030 and 2050 and to support the necessary building-retrofit market, the European project FASUDIR was established under the framework of a FP7 R&D program. FASUDIR provides an Integrated Decision Support Tool based on a new methodology supported by a software tool that helps decision makers to select the most suitable energy retrofitting strategy to increase the sustainability (economic, social and environmental) of a whole urban district. The Decision Support Methodology developed in FASUDIR guides planners of neighborhood retrofitting projects in a structured way through several phases of the project using the comprehensive support of an advanced web-based software tool.

2_Introduction

The current results of retrofitting interventions on building scale have shown that the effectivness of building retrofitting can be increased significantly through considering each building as a part of a global energy system in a district [6] [7]. This follows the approach of considering all buildings located in the same district as an entity. In this case the application of retrofitting measures is not limited to single buildings only but can be applied on district level through exploiting synergies and interactions between buildings and their surrounding infrastructure and environment. While planning retrofitting concepts for single buildings is a challenging task the complexity and work intensity for planners on district scale increases significantly. While acting on district scale planners have to consider how implemented measures on single buildings may affect the implementation of measures for other buildings located in the same district. Retrofitting measures on single buildings even may have negative impacts for other buildings or the whole district sustainability performance if they are not planned proactively. For instance the feasibility of establishing heat networks between buildings is strongly depending on the available heat demand density in an area. Thus, planners in district retrofitting projects have to assess if retrofitting measures on single buildings like improving the building envelop are more sustainable than connecting the buildings to a renewable driven heat network. In order to find the optimum solution in terms of sustainability for a whole district planners have to consider several criteria like the total impacts on the environment, the life cycle costs, the return of investment as well as social impacts of the planned measures. Moreover, in order to gather all the needed information for a sensible planning process and to achieve the most effective results planners have to cooperate with all involved stakeholders in a well-coordinated and structured way. Among others, representants of the municipalities, building owners, tenants, financing bodies and energy supplying companies have to be involved in all phases of the planning and implementation process. This presents a major challenge to planners of district retrofitting projects and can only be solved following a well-structured and thoughtful methodology which guides the planners and all involved stakeholders through the different phases of the project. To facilitate the planning on district scale and to improve the effectiveness of the planning and implementation process of energy retrofitting measures the use of an advanced and integrated planning and decision-support tool (IDST) is indispensable.

3_FASUDIR Methodology and description of the Integrated Decision-Support Tool (IDST)

3.1_Main targets and drivers for the FASUDIR methodology and IDST

In order to satisfy the need of holistic planning tools on district level need FASUDIR provides an Integrated Decision Support Tool (IDST) based on an innovative methodology, supported by a software tool. The IDST evaluates retrofitting needs of a set of buildings that share a common urban area and guides the decision makers in finding the optimum energy retrofitting strategy to increase the sustainability of the whole district. Understanding user requirements and their business objectives in undertaking potential district retrofitting projects is crucial to designing an effective decision support tool. With this in mind, at the beginning of the Methodology development an in-depth survey of a wide range of stakeholders was undertaken. The survey took place in Italy, Germany, Hungary, Spain and UK, being coordinated from London Business School and executed by the country-specific partners involved in the task. The stakeholders identified ranged from federal government planners through architects, technical advisers, local planners, energy suppliers and ESCOs to owners and social housing managers, covering district projects that range from three or four buildings to many thousands [3]. Potential users evidently value an approach that is easy to understand and helps to guide users' preferred solutions, though various constraints, to a well-structured, multi-criteria trade-off analysis. The results of the survey showed that FASUDIR will be applicable for different user styles of engagement. Mainly engaged will be technical staff and planners. However, the framework of the IDST allows all identified stakeholders to be involved in the different stages of district retrofitting projects by different functions of the IDST and different phases of the methodology. Through the high flexibility, the broad approach and the use of an plain language User Interface it is also possible for non-expert users in the fields of energy like facility managers, building owners or citizens to use the IDST for the creation of own retrofitting variants of their buildings and to visualize results. As the FASUDIR methodology takes advantage of the Pareto Principle sufficient accurate results can be obtained with acceptable effort and in short time.

3.2_The FASUDIR Decision-Support Methodology

The execution of district retrofitting projects is a very multifaceted task for planners and all involved stakeholders. Compared to building level projects the complexity on district scale grows exponentially while the data availability declines. So, planners need a sophisticated decision-support methodology to handle the complexity in an appropriate way. Therefore the FASUDIR Methodology divides district retrofitting projects into four main steps which planners can work off in a structured work process. The four steps are defined as followed:

- Preparation Phase
- Diagnosis Phase
- Decision-Making Phase
- Implementation Phase

3.2.1_Project Preparation Phase

The preparation phase is the foundation of each district retrofitting concept. In this phase all necessary data to create a citymodel for the use in FASUDIR is collected from several sources (GIS, CityGML, on-site inspection, owner and occupant surveys, etc.). The FASUDIR IDST supports planners in collecting the data by involving all stakeholders that may be able to provide needed data via an e-collaboration platform. Hence, planners are able to request data from different data providers in a structured data collection process.

Stakeholders are able to share digital data or to respond on the requests of the planners. E.g. owners, ESCOs or representants of municipalities are able to upload geodata files on the platform which can be utilised by the planners or a data manager. Owners and tenants can fill an online-survey which asks them several for the building characterisation necessary data, that cannot be obtained from default data or on-site inspection from the outside of the buildings (heating system, average number of occupants, measured energy data, etc.) (4). Planners use the e-collaboration platform as a supporting tool in the preparation phase. It supports them in acceleratíng the data collection by an improved information flow between planners and other stakeholders.

3.2.2_Project Diagnosis Phase

The next phase in the FASUDIR Methodology is called diagnosis phase. In this phase an evaluation of the current sustainability state is conducted and the useful targets for a district retrofitting project are defined. After the data entry process has been completed all necessary data to run a first simulation for assessing the current state of the whole district and all buildings in the district is available in the IDST Citymodel.

The current state is analyzed according to its global sustainability by the use of Key Performance Indicators (KPIs) which have been defined in the FASUDIR Methodology on building and district level [5]. To assess the current sustainability state of the district and each building the following in Table 2 listed KPIs are used:

Category	Indicator	Scale of Application
1. Ecologic Category	Total Primary Energy Demand	Multiscale
	Energy Demand in Operation (delivered)	Multiscale
	Energy Embodied	Multiscale
	Share of Renewable Energy on Site	Multiscale
	Global Warming Potential	Multiscale
	Acidification Potential	Multiscale
	Ozone Depletion Potential	Multiscale
	Eutrophication Potential	Multiscale
	Photochemical Ozone Creation Potential	Multiscale
	Abiotic Depletion Potential Elements	Multiscale
	Soil Sealing	District Scale
	Intensity of Water Treatment	District Scale
2. Social Category	Indoor Air Quality	Building Scale
	Thermal Comfort	Building Scale
	Visual Comfort	Building Scale
	Motor Transport Infrastructure	District Scale
	Public Transport Infrastructure	District Scale
	Accessibility to Infrasturcture	District Scale
	Urban Microclimate / Heat Island Effect	District Scale
	Gentrification Risk	District Scale
3. Economic Category	Life Cycle Costs (LCC)	Multiscale
	Return on Investment / Payback Period	Multiscale
	Change in value of property	Building Scale

Table 1. Key Performance Indicators of the FASUDIR Methodology with scale of application.

Thus, all KPIs are calculated by the IDST based on the simulation results. Additionally, each KPI is compared to a defined benchmark from the methodology which allows evaluating the KPI result compared to a sensible average value. This allows the user of the IDST to identify the strengths and weaknesses of the district in terms of sustainability. A low KPI value in this case means that the sustainability issues which the KPI addresses must be improved. To support the visualization of the KPI results to the user the IDST provides a special KPI Analysis Tool which is used every time the user wants to check KPI results. The KPI analysis tool also is used to assess the created energy variants in the decision-making phase. Moreover, to enable a detailed evaluation of the district's and building's results the user has the possibility to display selected raw data of the simulation results. These for example are the direct simulation outputs which are stored in the building and district result records of the Citymodel. The user therefore is able to access and display all data that is stored in the city model databases on a map. Thus, the user also has the possibility to export the data generated in the current state evaluation for further purposes beyond the FASUDIR IDST.

3.2.3_Project Decision-Making Phase

The decision-making phase is the third phase in the FASUDIR methodology. The decision-making phase enables the decision makers to define the district retrofitting project through the selection of the most sustainable retrofitting solution in terms. To achieve these objectives a structured methodological approach to fulfil all the needs has been developed. At the beginning the planners are able to create scenarios representing a district retrofitting project which are defined by setting measurable targets and objectives for the improvement of the KPIs. The target definition is based on the current state evaluation of the KPIs and is also linked to the e-collaboration platform. All involved stakeholders therefore can participate in the target definition process by giving votes on their targets and priorities.

Conception of Retrofitting Variants. After the main objectives for a project have been defined the planners are able to create different retrofitting variants. Therefore it is possible to select different retrofitting measures on building and district level from a pre-defined selection list. In order to apply only useful and technically feasible retrofitting measures on buildings it is essential to know which retrofitting measures work well or may not work for the buildings or whole groups of buildings. Even though planners of retrofitting variants may have a good knowledge about the feasibility of different retrofitting measures the Methodology supports and guides them in the selection process. Therefore, the IDST provides a comprehensive tool box with several useful analysis functions that help planners in evaluating the feasibility of different solutions.

The main challenge for planners in creating energy retrofitting variants for urban districts is to evaluate the impacts of different solutions onto the buildings and the energy supplying infrastructure in the district. Those synergies and interactions between buildings and the district were analysed deeply in the methodology development and can be assessed using the IDST. The provided retrofitting interventions in the IDST repository of technologies are classified according the following categories:

1. Reduction of energy consumption (consumer-driven)
2. Increasing the efficiency of the energy supply
3. Inclusion of renewable energy production

All categories contain several traditional off-the-shelf retrofitting measures as well as new innovative ones at building and district level. On building level it is possible to apply several envelop improvement measures (adding insulation, replacing windows, etc.), replace HVAC systems by more efficient ones, increase the efficiency of electrical appliances and to include renewable energy sources (photovoltaics, solar thermal systems, CHP, biomass fuel, etc.). On district scale, users can apply improvement measures in the fields of street lighting (LEDs), heating and cooling networks as well as renewable district energy systems (wind turbines, photovoltaic farms) and further. Moreover planners have the possibility to assess the improvement of non-energy related measures in a scenario like increasing the green spaces in the district or improving the accessibility to public transport stations. The KPIs are simulated and assessed for each variant representing the different applied retrofitting interventions.

Intervention Filter Logic based on constraints and restrictions on certain retrofitting measures. Although a variety of different retrofitting technologies is theoretically available for buildings and districts in the IDST the applicability of each technology in real life projects is often limited. Because of the fact that each district and even each building in a district is an individual case a lot of available retrofitting technologies cannot be implemented due to constraints and restrictions in different fields. To support the planners in considering all potential restrictions on interventions the IDST provides thoughtful filter logic. The filter logic is able to consider the different constraints and restrictions for the application of retrofitting interventions on each single building and the infrastructure by using the simulation outputs from the current state assessment. For example if a building in the district is under cultural heritage protection it can be set as a planning constraint in the preparation phase by the user. In this case external wall insulations will not be selectable for the user in the variant creation due to the filter logic. Moreover, the IDST takes advantage of simulation results generated through the current state assessment. For example if the suitability of roof or façade areas for solar energy on a building is not given this is automatically set as a constraint in the filter logic by the IDST. Hence, the IDST in this case is able to exclude solar based retrofitting technologies (photovoltaics, solar thermal systems) which exceed the available roof or façade area of a building by the use of the filter logic.

IDST Analysis Tools and Functions. Following special analysis tools and functions to support the variant creation are provided within the IDST:

1. Analysis tool assessing the energetic weak points of buildings

In order to prioritize different retrofitting measures to reduce the energy consumption and to increase the energy efficiency of a building it is necessary to know which represent from an energy view the weakest points of a building. This means the FASUDIR IDST supports the users in identifying the building components or systems which cause the highest energy losses and therefore, have with high probability the greatest energy saving potential. Hence, with the Energetic Weak Points Tool the FASUDIR user is be able to plan the retrofitting measures in a way that allows exploiting the most effective energy savings.

2. Tool assessing the feasibility of heat networks

The FASUDIR IDST provides a function that allows planners to assess the correlation between different retrofitting measures and the capability of heat networks for groups or the whole district. The function in the IDST calculates for user defined building groups or areas of the district a heat demand density map and visualizes it in 2D and 3D maps. By setting user defined thresholds the function shows the user the areas of a district or a city in which the construction of a heat network can be feasible.

3. Analysis tool for the assessment synergies and interactions between buildings

The functions shows the user the time-based load curves of the electricity consumption and the electricity generation (CHP, PV, Wind) of a group of buildings or the whole neighbourhood. Moreover it allows the user to assess how much electricity surplus is generated at which times to plan smart grids and electricity storages (charge e-vehicles, intelligent appliances).

4. Analysis Tool Assessing Solar potentials of Surface areas on Buildings and free spaces

The function shows the user for each building in the neighbourhood the suitability of roof and façade areas for photovoltaics or solar thermal systems (solar potential).

5. E-Collaboration Platform

The e-collaboration platform in the FASUDIR IDST is the central hub between the planners of a district retrofitting concept and all involved stakeholders and guests. The e-collaboration platform provides the framework to support the stakeholder involvement in each phase of the FASUDIR methodology. The platform is accessible via the main created project website of a district retrofitting project. Therefore, the e-collaboration platform enables the following features for the users:

- Online-Discussion-Forum (Citizen Participation, idea collection, etc.)
- Online Retrofitting Questionnaire (Owners, Tenants)
- Online cloud-based data storage for file exchange
- Front-page for announcements (News, Dates for Physical Workshops)

Variant Assessment for holistic comprising purposes in the decision making process. After planners have created variants the IDST is able to compare the variant to identify the most suitable one according to the set priorities of the decision-makers. In the assessment step of the methodology the users is supported by a decision-support tool. In this function all gathered information, conducted upstream analysis and generated data outputs in the different steps of the variant creation are finally stored in a database. The main input of the variants in the decision-support function is in the form of the KPIs results. The KPI results afterwards are used as core criteria in a value assessment to rank the different retrofitting variants according to the preferences of different stakeholders and decision-makers. Thus, planners of retrofitting concepts have a powerful and logic feature to support the complex decision-making process in energy retrofitting projects for urban districts. In order to be able to conduct a value assessment based on a Multi-Criteria-Decision-Analysis (MCDA) approach the valid variants are ranked according to the preferences and priorities of the decision-makers. For all created retrofitting variants the different KPIs are simulated by the IDST. To set the priorities the IDST provides a Decision Support Tool which allows the FASUDIR Users to enter their priorities from a list through a plain language entry mask. The plain language entry mask translates priorities in a weighting system. Hence, the weights for the different KPIs in the value assessment are adjusted automatically.

Project Implementation Phase. The implementation phase is the last phase of a district retrofitting project in the FASUDIR Methodology. In the implementation phase the best ranked variant of the district retrofitting concept has to be practically implemented. Therefore it is the longest phase in a district retrofitting project and can last from 2 years up to 20 years or even longer depending on the motivation of the stakeholders and owners. The focus of the FASUDIR Methodology therefore is not the complex work of planning the detailed retrofitting construction process. This task should be done by a retrofitting manager who has the final responsibility for the coordination of the retrofitting construction process. However, FASUDIR supports the complex work of the retrofitting manager by the IDST and the related supporting tools. To achieve this, the IDST provides an update and monitoring function which allows updating and monitoring the current state of the district according to the already implemented retrofitting measures by the owners. The updated current state can be compared to the targets that have been defined in the scenario. Thus, the retrofitting manager and the represents of the municipality have the possibility to check the current progress during the whole implementation phase. This is very important in order to control the retrofitting progress and to identify obstructions which have negative impacts of the retrofitting work. Based on the results the retrofitting manager is able to develop suggestions for improvements (e.g new grants, change of the variants) and to recommend them to the stakeholders. Moreover, the achieved successes in the retrofitting project can be shown and demonstrated to politicians, stakeholders and citizens by using the IDST. Furthermore, the IDST supports the retrofitting manager in improving the communication flows between the stakeholders in the implementation phase through the e-collaboration platform. Hence, the retrofitting manager is able to contact all stakeholders in an optimized way via the internet. This facilitates the mediation between different stakeholders which is very important in the implementation process of district solutions.

4_Discussion

In fact it is very difficult to assess the uncertainties that may occur in district retrofitting concepts. However, the goal of district retrofitting concepts and the district approach in general is not to provide as detailed results and calculations as possible but to help planners and stakeholders to find the right direction for the whole district. As the data collection in a district is not as detailed as for building retrofitting concepts the uncertainties are higher on district level. However, the time effort for the data collection can be reduced by up to 80% compared to a detailed data collection. Therefore the Pareto principle states those, for many events, roughly 80% of the effects come from 20% of the causes. If the Pareto Principle is applied to the data collection process for buildings and districts 80% of the accuracy can be reached with 20% of the time and cost effort. If the planners need to have 100% accuracy the time effort for the data collection will be increased by 80%. FASUDIR therefore is created as a tool for high level insights and therefore takes advantage of the Pareto Principle.

5_Conclusion

Besides the planning of concepts, the practical implementation of the measures cannot be done by software tools as a deep interaction and communication between all involved stakeholders is necessary. Hence, the planning and practical implementation of district retrofitting projects is a task that is due to its high complexity still strongly dependent on the human intelligence of professionals and experts. However, the professional planners can take advantage of structured approaches and supporting software tools to make their work more efficient. Against this background the Decision-Support Methodology must be regarded as a stand-alone approach which is not directly coupled to tools or software. This means, that the FASUDIR Decision-Support Methodology in general is applicable without the use of the FASUDIR IDST. However, to follow all steps included in the different phases may need a lot of time and partially be not effective without using appropriate support by the IDST. Vice versa the IDST also cannot be seen as a stand-alone tool. Using the IDST in an appropriate way needs to follow the structured Decision-Support Methodology in order to achieve meaningful and resilient results. Only the joined use of the Decision-Support Methodology and the IDST ensures an efficient work flow and increases the probability for a successful completion of district retrofitting projects. The development of the FASUDIR Decision-Support Methodology and the IDST will significantly improve the currently used methods of operating in district retrofitting projects and facilitate keeping the the EU's "40-27-27" targets for the building sector.

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INTERACTIVE VISUALIZATION TOOL (INVITO): A WEB VISUAL TOOL FOR SHARING INFORMATION IN TERRITORIAL DECISION-MAKING PROCESSES

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decision processes
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Abstract

Territorial planning is the focus of considerable debates, which often develop into uncertain and vulnerable decision contexts.
Numbers and quantitative information in fact often dominate the process of decision-making but they are not easily comprehensible through quick and simple reasoning. Nonetheless, the huge quantities of data that describe our cities and regions could provide excellent bases to analyze spatial data in order to assess territories and simulate future development scenarios.
The application of innovative digital tools in the analysis of urban issues offers new advantages and opportunities for the improvement of communication values in policies and decision-making processes, concurring to overcome conventional approaches to territorial management.
The paper describes the application of the Interactive Visualization Tool (InViTo), a web tool based on maps and visual analysis allowing data to be filtered, explored, interconnected and compared on a visual interface.
Data visualization, intended as the way to see the unseen (McCormick et al., 1987), is here used as a new paradigm to highlight the positive and negative effects on spatial systems considering the impacts of choice-alternatives along multiple dimensions. The correlation between information and their localization generates an essential instrument for the knowledge of urban dynamics and resilience in answering to specific policies.
The investigation of a number of case studies shows the possibilities and opportunities given by the use of InViTo in creating a shared knowledge between actors involved in decision-making processes and in offering a challenge for integrating new perspectives on the analysis of future cities and regions.

1_Introduction

The on-going urbanization has lead to an increased focus on cities (UN, 2012) highlighting their inability to offer adequate facilities to their population. In fact, such complex congregation of people tend to become disordered places (Johnson, 2008) generating sets of material and non-material problems. The first set comprises among others difficulty in waste management, scarcity of resources, traffic congestions, aging infrastructures and energy management (Borja, 2007; Marceau, 2008; Toppeta, 2010; Washburn et al., 2010). The set of non-material problems are instead related to social and organisational matters associated "with multiple and diverse stakeholders, high levels of interdependence, competing objectives and values as well as social and political complexity" (Johnson, 2008; Weber and Khademian, 2008; Dawes et al., 2009; Chourabi et al., 2012).
In this sense, urban and social issues can be considered as "wicked problems" (Rittel & Webber, 1973) creating potential conflicts and unanticipated effects. Due to the complexity of the cities, the mission of an urban project is never so clear including a wide number of data, variables, parameters, indexes and qualitative elements usually barely measurable.
Moreover, while in the past one of the difficulties in urban planning was the lack of data-measuring activities, nowadays the problem is the opposite: there is a huge amount of quantitative and qualitative data but they are often

difficult to read. Therefore, databases need to be not simply able to visualise data but also to extract and process usable information (Belton and Pictet, 1997; Mingers and Rosenhead, 2004; Belton and Stewart, 2010; White, 2006; Montibeller et al., 2008; Pensa et al., 2014; Lami and Franco, 2016).
The application of Information and Communication Technology (ICT) is often mentioned as part of the solution to those complex problems and the term 'smart city' is increasingly being used in this context (Hilty et al., 2011; Lövehagen and Bondesson, 2013).
However, despite that ICT are definitely enhancing the opportunities for spatial planning changing the common vision of the social inclusion (Goodspeed, 2011; 2012; Resch, Summa, Sagl, Zeile, & Exner, 2014;) they often present huge difficulties in being applied in daily practice (te Brömmelstroet, 2010; Vonk, Geertman, & Schot, 2005): 1) it takes a long time to calculate results which hinder the interaction between data models and users; 2) data models generally have low flexibility to adjust to specific needs; 3) most of these support systems have limited abilities in communication.
Communication is in fact one of the main features to be considered when talking about effectiveness of ICT for smart cities but the approach of communication by simply "writing down your objectives and stating your priorities, is inadequate for decisions worthy of thought" (Keeney, 2013; Lami et al., 2014).
Thus, spatial planning is currently encountering new approaches to the use of technology. In particular, both the academic researchers and professionals are increasing their interest in data-driven methods (Kamenetz, 2013; Lanzerotti, Bradach, Sud, & Barmeier, 2013; Kokalitcheva, 2014) investigating new tools in order to allow information to be easily extracted from data and disclosed to the stakeholders involved in a urban planning process (Bawa-Cavia, 2010; Neuhaus, 2011; Chua, Marcheggiani, Serrvillo, & Vande Moere, 2014).
In this context, the paper investigates three case studies describing the application of the Interactive Visualization Tool (InViTo). InViTo is a web tool based on maps and visual analysis allowing data to be filtered, explored, interconnected and compared on a visual interface (Pensa et al., 2014). The aim of InViTo is to built a shared basis of discussion among the actors involved being interactive in order to allow adjustments during a urban processes. Furthermore, InViTo offers a way to represent different typologies of geo-referenced data and to combine them in order to visualise the "hidden connections" (Dodge, 2005) among these data.
After the introduction the paper is organized as follows: section 2 reports the methodology adopted focussing on the development of the InViTo tool; section 3 shows some examples of applications of InViTo; finally, the conclusions resume the potentialities of the methodology adopted and further developments.

2_Methodology

2.1_The InViTo tool

Developed in 2011 (Pensa and Masala, 2014) as a visual support for spatial planning and decision-making processes, InViTo is conceived as a toolbox for supporting the analysis, the exploration, the visualisation and communication of data in order to facilitate policy and decision-making, improving the communication between actors coming from different backgrounds.

In its current version, InViTo can be classified within the category of spatial Decision Support System (sDSS) (Malczewski, 1999) as a Web-GIS tool. In fact, it is a web platform conceived to present GIS data and let people to play with those in order to increase the level of knowledge on spatial issues among both expert and non-expert people. Nevertheless, new developments allow the exploration of non-spatial data too, so that interactive info-graphics can be visualised and analysed.

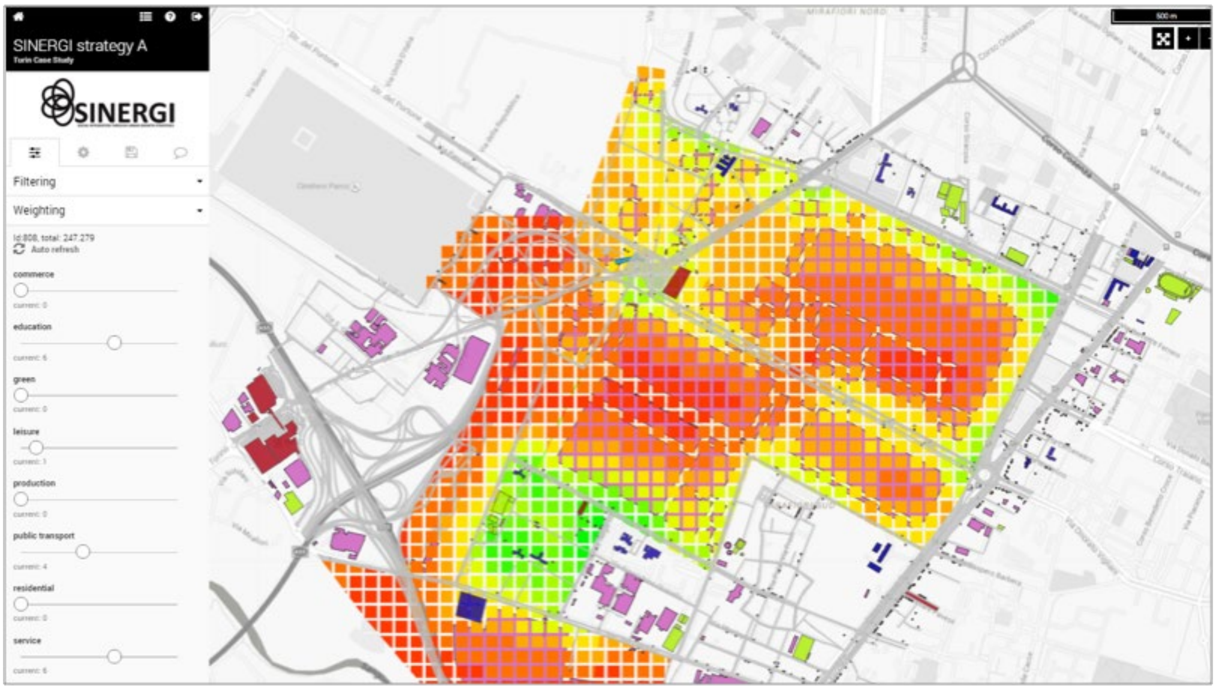
The building of a web platform structure was the first essential step to develop the instrument creating the general framework of the tool. Its building took several months and has been progressively adapted to the development of other elements composing the tool. In order to be really accessible, the tool was based on an open source structure and open source initiatives.

InViTo is composed by two main sections: the back-end and the front interface.

The **back-end** is destined for GIS technicians, planners and administrators of projects. Here the logged-in users can create new projects and manage existing ones deciding the information that need to be seen by final users. Moreover, in the back-end interface, the logged-in users can decide the filter modality choosing among checkbox, dropdown menu, range sliders or single choice range sliders. Finally, specific buttons provide possibilities for customising the visualisation or for enabling particular elements such as tables, analysis grids or background maps.

The **front interface** is destined for final users. In fact it can be public and allow people visualizing, filtering and exploring data related to specific projects. The front-end interface is graphically structured by two main elements: a viewer window containing an interactive map and a vertical menu on the left side containing all the parameters settled by the logged-in users in the back-end interface (Figure 1).

Figure 1. Front interface of InViTo: a window containing an interactive map on the main frame and a vertical menu on the left side.



The structure of the front interface can be in turn divided into three subsections: data filtering, map weighting and data visualization.

The **data filtering** section allows data to be interactively selected and filtered by the end users in order to customise the visualisation. Despite basically InViTo works as other GIS viewers, it does not visualise only the different layers of a set of data, but it allows users to explore the single records of a dataset by the use of different kind of pre settled filters. Moreover, the filters can be grouped in panels, so that the visualisation can be driven through a particular path to follow. Moreover, InViTo allows data to be investigated at different levels with also intersection of attributes, in order to analyse data clusters in relation to specific parameters. In this sense, InViTo overcome the data-map representation to arrive to the visualisation, intended as the discipline to see the unseen (McCormick, De Fanti, & Brown, 1987).

The **map weighting** section allows the filtered maps to be overlapped and weighted on the basis of their priority. The aim of the map weighting section is to provide users with a tool for analysing the localisation of expected effect of specific elements and evaluating the sum of effects on the basis of a specific mathematical curve associated to the layers. This section is an on-going part of the research. In fact, the map weighting is currently based on the sum of maps as in the basic methodology of Multicriteria Decision Analysis (MCDA - Figueira et al., 2005). Further developments of InViTo will improve this section in order to integrate the opportunity to develop MCDA directly in the tool as the spatial Multicriteria Analyses combining GIS and MCDA (Malczewski, 1999; Ferretti, 2013).

The **data visualization** settings allows a high level of customization on colours, dimensions, styles, map styles (between Open Street Maps or different Google Maps styles) and on a series of utilities by means of which the tool is expected to offer a wide range of possibilities for users to improve their analytical skills and enhancing the discussion. Furthermore, users can visualize tables and charts showing data according to the filters activated in the filtering section. The tables show the attributes related to the filtered data, providing pre settled additional information field by field. The charts show the values of the filtered data in relation to the whole set of data, highlighting the selected geometries.

The distinctive features of InViTo are therefore dynamicity and interactivity, which make it open to variously skilled users and suitable to be part of instrumental equipment for meetings and workshops. In fact, it can be used by a single person or collectively during discussion sessions. In this case the displayed map can become the interface for sharing opinions and reasoning. In fact, its quick responses and visual interface offers possibilities for improving the discussion among people, providing a shared basis for enhancing the debate.

3_Case studies

Spatial decisions and policymaking processes affect, or can affect, the geography of an area at different spatial scales. This can happen with a very wide spectrum of consequences, which can be studied by different discipline

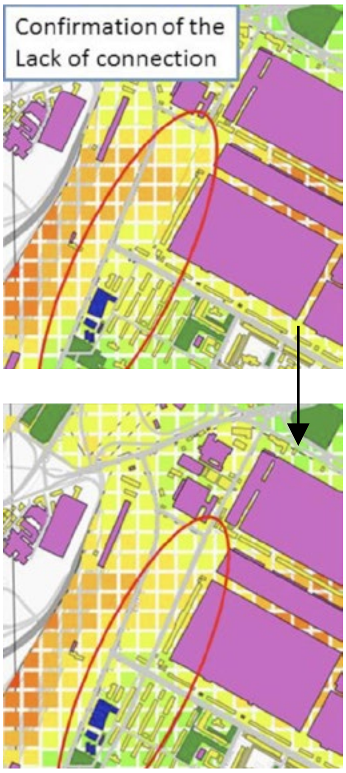


Figure 2. The use of InViTo during the second SINERGI workshop, Turin, June 2015: identification of an existing infrastructural lack (left) and checking of a design idea for a new road (right).

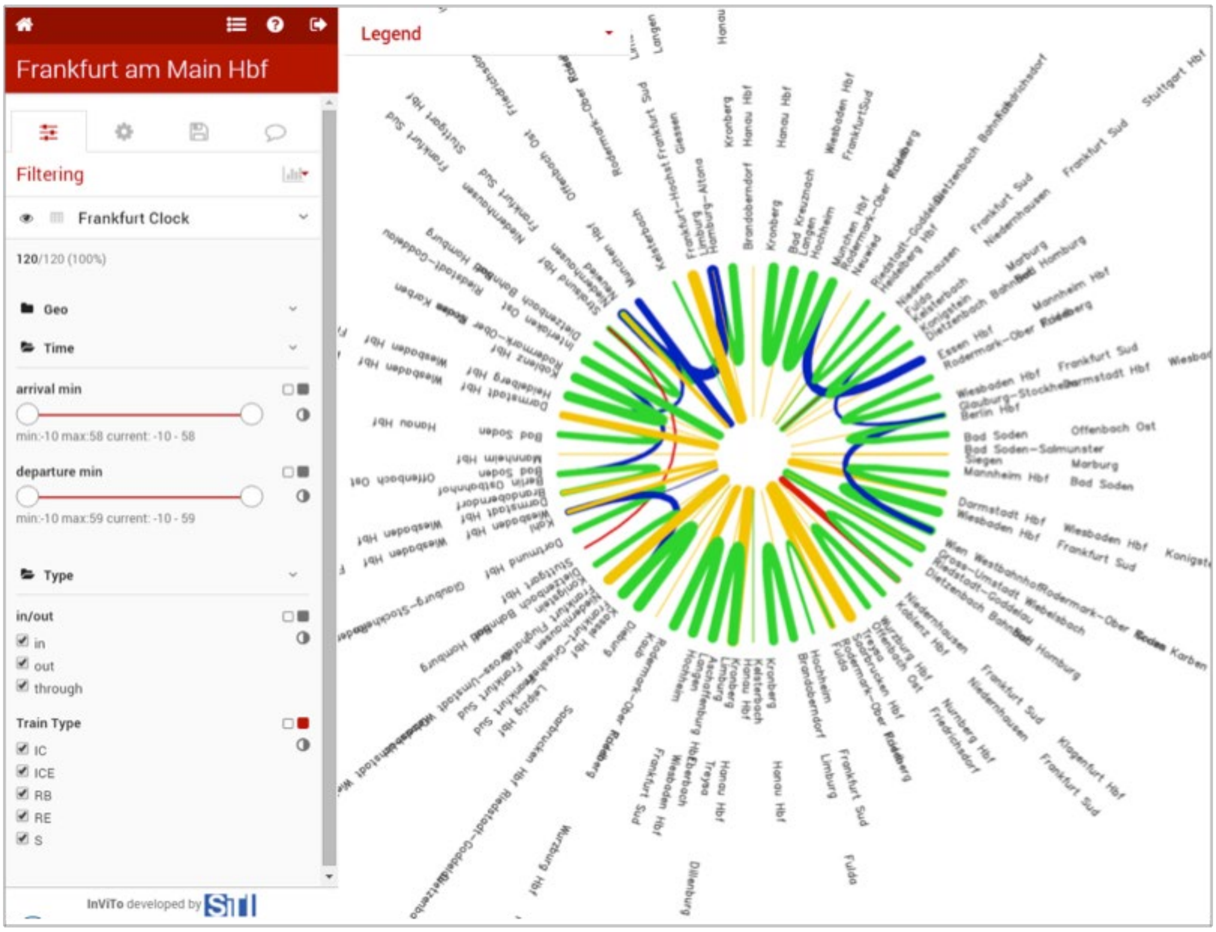
fields such as urban planning, transport planning, mobility, environment, social and economic sciences. The InViTo structure was conceived as open as possible in order to avoid constraints in the use of the tool. Thus, it can be used for dealing with different case studies, with different purposes and afferent to various disciplines. The following three case studies show some example of applications of InViTo.

3.1_SINERGI project

The Social Inclusion through Urban Growth Strategies (SINERGI) is a project funded by the "Europe for Citizens" programme. It involved four cities as Skopje, Lisbon, Turin and Zagreb, in a number of seminars and workshops oriented to the improvement of the process of social inclusion within the urban planning.
In order to achieve the project objective, InViTo has been chosen to perform the SINERGI workshops. The first workshop was held in Skopje in December 2014 and was focused on the evaluation of three infrastructural scenarios for an urban area in the same city. The second workshop was held in Turin in June 2015 and concerned the renewal of a huge dismissed urban area with an industrial past and many future projects insisting on it (Figure 2).
Both the workshops had a diversified public, composed by city administrators, technicians, academics, students and social representatives. A number of discussions emerged outlining possibilities and opportunities given by the use of interactive maps designed to facilitate and improve the interaction between the information and the actors involved in the planning process.
The tool has been used to detect critical areas and areas with more opportunities. After the discussion of some design alternative options, InViTo has been applied to evaluate "what if" scenarios. The outcome provided by the tool gave no solutions, but opportunities for the participants involved in the workshops to discuss and elaborate a shared solution.

3.2_CODE24 project

During an Interreg IVB NWE Project named "CoDe24" (INTERREG IVB NWE, 2005; ERDF European Territorial Cooperation 2007-2013, 2010), the Interactive Visualisation Tool has been used for several events and purposes. One of these concerned the exploration of the total number of trains arriving and departing from the Frankfurt am Main railway station between 8.00 a.m. and 9.00 p.m. of a common working day (Figure 3).
The visualisation of data is interactive. Users can choose the setting and filtering of a number of parameters, such as the train typologies, the city of origin or the city of destination. Unlike other projects, in this case the represented data are not spatial. They are organized within an info-graphic without background maps or geographical references. The geographic information is restricted in the selection of filters.
The online use of this application provided the possibility to share the information between the partners of the project. Furthermore, it generated an intuitive visualisation of the railway connections of an important city like Frankfurt am Main, the train arriving, outgoing or passing by the city, the typology of the trains and the possible integrations among the different trains.



Colours and thickness of lines change according to the setting made by the users, providing further information on the selected elements.

Figure 3. The use of InViTo for visualising the railway connections of Frankfurt am Main between 8.00 a.m. and 9.00 p.m.

3.3_Tweets in Barcelona

A third case study concerns the visualization of tweets sent from the metropolitan area of Barcelona in the period January 7-19, 2015. The research is part of the TUD COST Action TU1306 - Fostering knowledge about the relationship between Information and Communication Technologies and Public Spaces supported by strategies to improve their use and attractiveness (CYBERPARKS). The objective of the research was the improving of the design of public open spaces by means of information captured by the analysis of user-generated data.

The data collected from Twitter have been elaborated and uploaded in InViTo. The visualisation allows users to interact with a large amount of data (more than 67.000 records) and to understand the urban patterns generated by Twitter's users by the self-exploration.

The large amount of maps that can be obtained by such a data exploration is sufficient to identify several urban patterns and understand some dynamics on the use of the city. In particular, the tool showed to be very important for analysing the tweets following both a spatial and a temporal logic. The differences in tweets spatial distribution according to the temporal period selected provided new insights on the analysis of the city. These outcomes highlighted a number of issues related to the tourism and the use of the city in relation to the origin country of people visiting Barcelona.

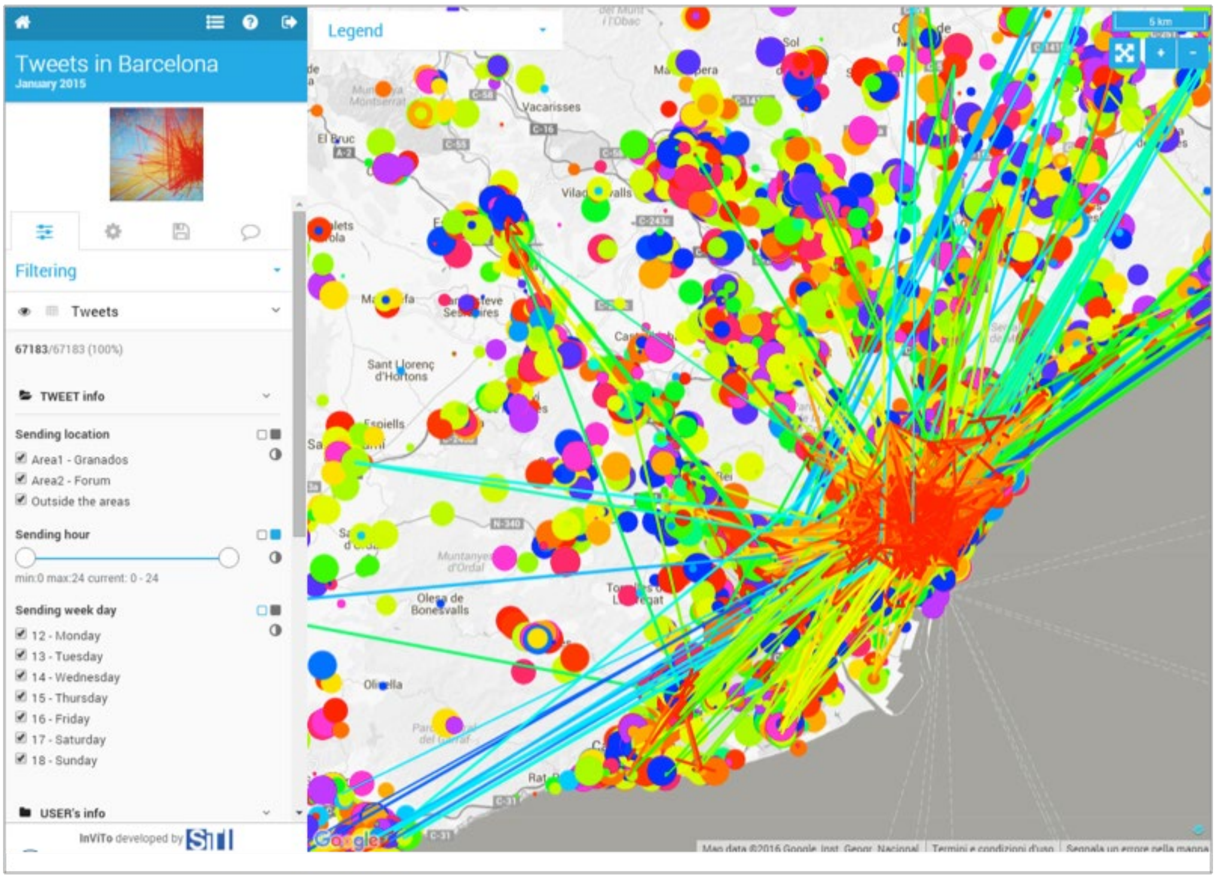


Figure 4. The visualisation of Twitter Data in Barcelona, collected in January 2015.

4_Conclusions

The three case studies are a small example of possibilities in applying the tool. The high level of customisation of the filtering and weighting sections as well as of the visualisation provide a large amount of opportunities for the information sharing between large groups of people. The use of visualisation goes against a technocratic vision of cities and increases the power of experts. It allows planners, city administrators, technicians, but also common citizens, to improve their awareness of urban problems. A higher knowledge enhances the decision-making process, providing opportunities for better choices.

Furthermore, a high flexibility of the tool allows the instrument to be adapted to the case study and not, as often, the planning adapted to the possibilities given by the tool. By this way, the urban tool is not a constraint but a real support to the urban planning.

Future developments of InViTo will foreseen the improvement of the MCDA section currently drafted in the tool in order to better weight the maps provided and enhance the usability of InViTo in supporting urban planning.

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BIM-GIS MODELLING FOR SUSTAINABLE URBAN DEVELOPMENT

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smart urban district
living lab

Abstract

The subject of energy efficient buildings incorporated into the district is one of the greatest and most challenging of research priorities in the European Union. In this context the potentiality and benefits of the integration of Geographic Information System (GIS) – Building Information Modelling (BIM) are explored as an integrated methodology for data collection and management relating to existing buildings. The aim of this study is to create a graphical database mainly based on information that is already available on a building stock, which it will be used to evaluate the energy consumption profile at building and district scale. For this purpose, it is necessary to develop an urban model able to contain heterogeneous data considering different Levels of Development and different Levels of Detail (LOD), which can be exploited for many purposes including design, maintenance or refurbishment of buildings and energy consumption monitoring. In this way, data can be extracted for a specific calculation in different applications for assessing and supporting decision making in order to achieve sustainable urban planning. This paper is part of an ongoing Smart City research, a national cluster project named Zero Energy Buildings in Smart Urban Districts (EEB), which aims to increase energy efficiency of buildings, especially at the global level of urban districts.

1_Introduction

The building sector accounts for about 30% of global annual greenhouse gas emissions (GHG) and consumes up to 40% of all energy (UNEP, 2009). Consequently, policymakers have recognized the potential of this sector to increase intelligent and sustainable buildings with the aim of reducing CO_2 emissions and energy consumption, which are main concern in the EU. In this sense, government actions have to take into account energy security and promote a transition towards decarbonized energy sources without debilitating well-being (Lombardi, 2014). Almost 67% of the total energy consumption and 70% of GHG are caused by cities' activities, as reported by the Intergovernmental Panel on Climate Change (IPCC, 2014). Therefore, the future Smarter Cities will drive sustainable economic growth, therefore a focus of urban areas is required as they are the largest consumers of energy in the EU.
To avoid an extra growth of these values, the EU has defined an energy efficiency plan, setting several policy targets of the 20-20-20: (i) 20% reduction in EU greenhouse gas emissions from 1990 levels; (ii) raising the share of EU energy consumption produced from renewable resources to 20%; (iii) 20% energy efficiency improvement (COM(2011) 109 final). Subsequent target published by the European Commission, known as a Roadmap 2050, aims at moving towards a competitive low-carbon economy, setting out a scenario to meet the long-term target of reducing emissions by 80 to 95% compared to 1990 levels (COM(2011) 112 final). These targets stress the significance of speeding up renovation actions in buildings sector. In the past, the single energy performance has been significant rather than a large building scale. Currently, it is much more important to take into account the buildings' energy efficient assessment into the district (Kocha et al., 2012). Therefore, where the goal is the evaluation of the greenhouse gases reduced emissions and

global achievable energy savings, it is necessary to broaden the study on the buildings at a territorial scale (Fracastoro and Serraino, 2011). Consequently, there are many studies in the construction, operation and design of energy efficiency buildings in the community to be met in order to provide the information model of the district (Sebastian et al., 2013).

This study, conducted as part of a national cluster project, illustrates the development of a District Information Modelling (DIM) regards to energy consumption saving. The main goal of DIM is to manage energy consumption problems of existing stocks and the historical ones, including the processes of maintenance based on a series of ICT components at district level (Lombardi et al., 2014). Moreover, the increasing advance of Information and Communication Technology (ICT) in addition to Building Information Modelling have been supported the digital organization of building characteristics and parameters. When talking about the district level, GIS should integrated with BIM and create 3D data models that offer information about buildings and their surrounding contest at district level. BIM involves building's digital information management which can be integrated through ICT to control and monitoring systems. While GIS is a broad system that can arrange many different process and technologies as storing, capturing, managing, analyzing, and presenting all sorts of spatial or geo-referenced data. Furthermore, using GIS have many advantages, for instance, it can add the environmental information to the detailed BIM information. In relation to this purpose, several studies as well as European projects (Del Giudice et al., 2014) have been carried out, showing the benefits of the GIS-BIM integration at urban level.

Actually, final-users can increase the awareness about their behavioral impact on energy usage through real-time feedbacks, provided by visualization tools. ICT, as a matter of fact, makes possible the integration of data from various sources in a unified way, such as building information models, information about systems (air conditioning and lighting), environmental sensor networks, analytic models for the energy consumption calculations, tools for data viewing (tablets and smartphones). In this perspective, a collaboration framework between the ICT and the different discipline of the building industry is established aimed at exploiting opportunities for manage and exchange energy and facility management data in compliance with the Buildings' Energy Performance Directive. It is verified that users by efficient control and visualization technologies reduce their consumption (Levin, 2015). By open source database users will be able to monitoring and control their utilities in a more intelligent way in order to reduce their energy usage.

2_Methodology

Nowadays an increasing number of cities are equipping themselves with urban three-dimensional virtual models as an instrument for integration and management of both spatial and semantic data. Within the project's purposes, a double methodological approach has been investigated in order to set up an urban-scale information model, useful for making energy and facility management assessments in an integrated manner. Through the GIS model,

in fact, an overall view of the district or city, as well as easy cross querying data, is enabled, while BIM models provide a comprehensive representation of a single building or compound. Isikdag et al. employed the proof-of-concept to transfer geometric and semantic information of the building basics into the geospatial environment. The results of their research confirmed that BIM offers an adequate level and amount of information – about the building – for the seamless automation of data management tasks in the site selection and fire response management (Isikdag et al., 2008). In this framework, particular attention needs to be paid to the Level of Detail and Development (LOD) of data in these different environments to achieve a coherent system. A common and shared elements' definition, regardless of the tool used, allows to define the level of reliability of models and related information and to identify potential uses (costs estimation, coordination or analysis). Level of Detail is essentially the amount of graphic specifications that are included in a model element; while Level of Development stands for the element's degree of progress into the whole model definition, either in terms of its geometry or attached data (non-graphic information that may be relevant) (AIA, 2013). The challenge of BIM is to implement Level of Detail as an input considering Level of Development as an output, since it represents the reliability of elements when different stakeholders using the model. In this way, LOD gives the rules to follow for the minimum requirements of the model elements so it enables easier collaboration between different operators involved in the Architecture, Engineering, Construction and Owner-operated (AECO) industry during the building process. The CityGML standard denotes that LODs are required to reflect independent data collection processes with differing application requirements. Furthermore, LODs facilitate efficient visualisation and data analysis (Open Geospatial Consortium, 2012). In a CityGML dataset, the same object may be represented in different LOD simultaneously, enabling the analysis and visualisation of the same object with regard to different degrees of resolution. Furthermore, two CityGML data sets containing the same object in different LOD may be combined and integrated.
The integrated management of heterogeneous information source city-wide involves a series of new applications that could take advantage from a unique database containing detailed information on buildings as well as other relevant entities for urban planning. However, the urban models are complex systems that can be queried and managed in different correlated representation scales – building, district and city. To achieve this goal, both a large amount of data must be handled and geometric representations must be consistent between levels. It can be affirmed that the large scale information can be easily implemented in a GIS system, contrariwise, the building's characteristics are already stored in the BIM environment and only a few of this data is collected at the urban level. As regards the district, instead, a balanced mix between GIS and BIM data is required in order to improve the decision processes and the information system. To carry out assessments in the energy field, for example, both general data – such as location, orientation, dimension, utilization, energy consumption – and building envelope characterization and plant – renewable energies – are necessary. Actually

collecting and displaying data connected with business at a district-level is still considered a critical point within the process, as well as an interesting field of research.

2.1_Case Study

The methodology, based on BIM-GIS modelling, has been applied to Settimo Torinese, a municipality in Piedmont, North-West part of Italy. The main aim of these experimentations is to show that the energy efficient strategy for a Smart City of the future should start on its historic city center and extend gradually to the entire city. This municipality of the metropolitan area of Turin represents a good demonstrator for testing new technologies for: (i) its inclusion in the context of a district with historic buildings and other buildings can be exemplified by type, size and age of construction; (ii) the ability to control over the distribution network by a single stakeholder, (iii) its possible reproducibility in other Italian cities; (iv) existence of different types of buildings from the retrofitting point of view. Moreover the City is proactive towards initiatives related to technological innovation and smart cities. The City, in fact, provides for some years to its citizens the opportunity to surf for free with their personal computer, using the wi-fi networks active in the city squares and major public buildings, such as the Library Archimedes, the Living Museum, the town halls of freedom Square, the seat of the municipal police. However, the existing built has still necessary to overcome a difficulty of integration of intelligent technologies and systems for energy management to ensure an economic return on investment.
According to energy consumption analyses, reported by the North-East Turin Union of Municipalities (NET) (i.e. Borgaro Torinese, Caselle Torinese, San Benigno Canavese, San Mauro Torinese, Settimo Torinese, Volpiano), the total energy consumption was equal to 3,252 GWh in 2009 for a population density of 535 ab/ km² (Figure 1). The highest value is referred to the industrial sector (36% of the total) and it is also significant for residential (27%) and transport sector (26%). The public sector accounted for a share of 1% of total consumption. Compared to 2000, the first available year for historical values, there was an overall consumption decline for about 8.5% (SEAP, 2012).

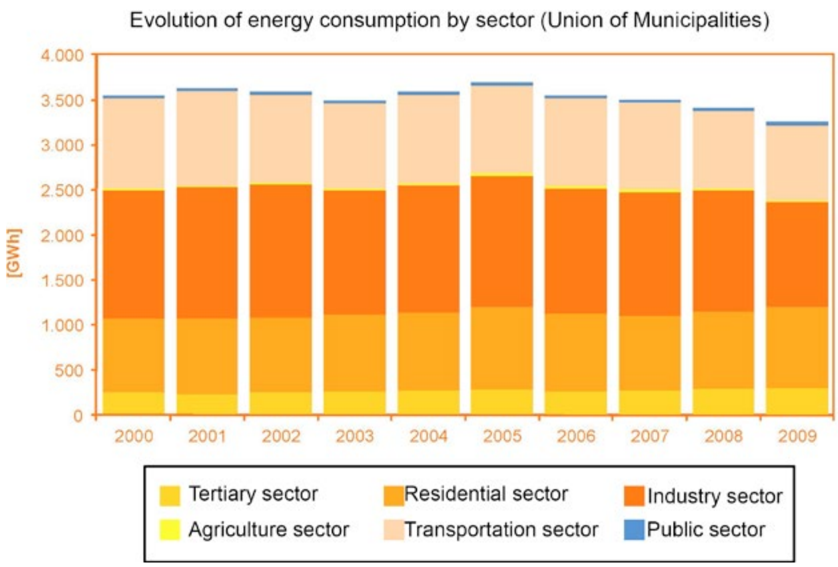
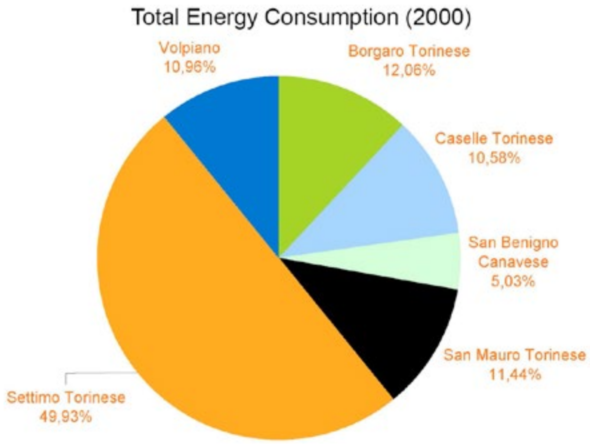


Figure 1. Evolution of energy consumption by sector in the North-East Turin Union of Municipalities, Source: SEAP, 2012.



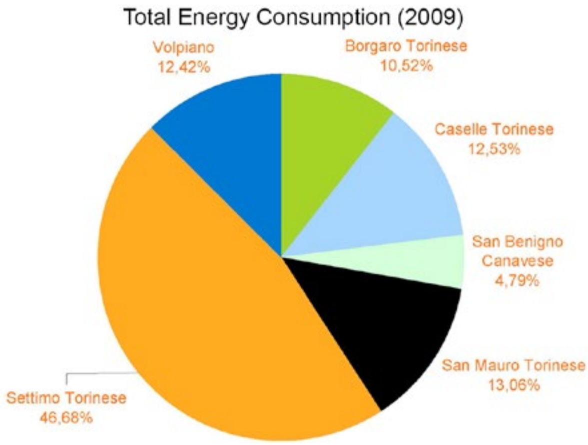


Figure 2. Energy Consumption Percentage for Union of the NET (a) 2000 (b) 2009. Source: SEAP, 2012.

Figure 2 highlights the percentage of the energy consumption for each municipality belonging to the union of the North-East of Turin. Immediately, it is noted that the Municipality of Settimo Torinese is the most energy consumer both in 2000 and 2009 for about half of the total energy consumption respectively 49.93% and 46.68%, amounting for about 40% of the a total population in 2009 (Table 1).

Table 1. Socio-demographic characteristics, Source: SEAP, 2012.

Municipality	Population 2009	Number of Buildings	Number of Accommodation	Number of family
Borgaro Torinese	13535	757	5305	5283
Caselle Torinese	18060	2227	7642	7342
San Benigno Canavese	5596	1190	2509	2264
San Mauro Torinese	19324	2525	8408	8162
Settimo Torinese	47713	3478	20120	20036
Volpiano	14954	2660	6197	5997

2.2_GIS

When several different sub-systems are put together, they can provide the structure of an urban area that is a very complex dynamic system. To analyse this kind of system, GIS as a comprehensive tool provides a city model structured according to several layers and geo-referenced data (Azzena, 1995). Although the building stock is the largest cultural, social, physical and economic capital of most societies, the lack of data has blocked the long-term scenarios development (Lomas, 2009). Actually, GIS is a digital tool that became as a strong and useful support system for analysing and managing big data. Geo-referencing the data, each item is placed in a proper system of coordinates, being associated with a geometric entity. Therefore, GIS is helpful for urban energy planning as well, this fact is also highlighted by many studies, for example, Bugs et al. (2010). Accordingly, there are many opportunities to make decisions in order to achieve a better level of sustainability of areas, and supporting suitable urban planning. On the other hand, GIS visualization could be expanded for building related environmental data by associating it to building stock (e.g. energy consumption can be associated to group of buildings) (Delmastro et al., 2015). As conducted by Nghi and Kammeier in 2011, various sources can be integrated to make available better information on which can make decisions for sustainable urban planning (Nghi and Kammeier, 2001;

Mutani and Vicentini, 2013). The proposed method differs from the others, especially for determining the energy performance of buildings.
The presented results in the urban energy maps are useful for a global overview of the energy performances of cities. The common goal of different methodologies is to provide the most complete framework of the energy efficiency characteristics of existing building stock. Recently, the impact of heritage buildings on the overall energy demand of Ferrara and Torino (Italy) was investigated. These studies considered the influence of the energy incidence of buildings according with their characteristics in terms of geometry and thermo-physics proprieties, using GIS maps as a strong platform for linking a different data (Fabbri et al., 2012; Mutani and Vicentini, 2015). Thereupon, the use of GIS permits the acquisition, archiving, analysis, and geo-referenced visualization of various data levels related to an urban areas. At urban scale GIS helps evaluation and identifies critical points of potential energy improvements with reference to energy performances (Ascione et al., 2012). Accordingly, the results presented in the urban energy maps are beneficial to have a broad overview of the energy performances of cities (Torabi Moghadam et al., 2016).

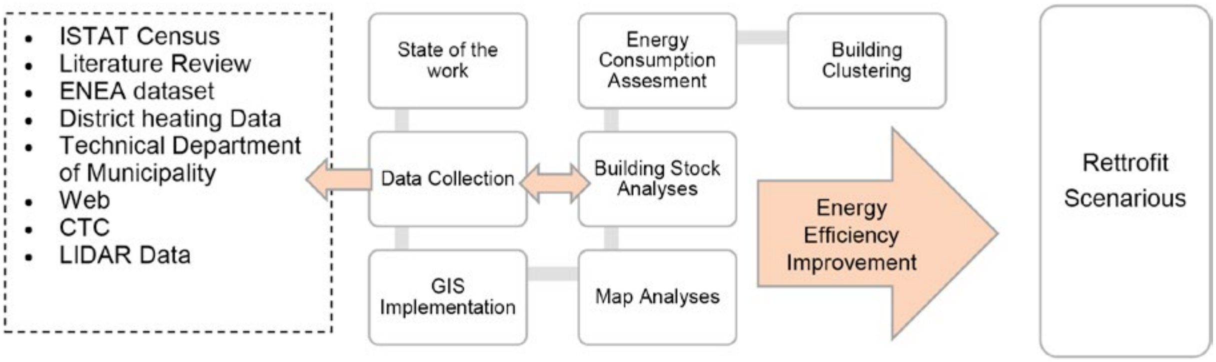


Figure 3. Proposed methodology, Source: Own Authors.

At first, a model based on energy consumption data has been produced to assess energy demand within the EEB project; then different savings scenarios will be assumed. Such model can be used by energy planners, energy suppliers and decision makers to compare and evaluate the effect of a broad range of energy efficiency procedures and technology strategies on the energy consumption and GHG emissions of the building sector. From building stock's detailed spatial representation, which it is also characterized by socio-economic census, this model can be implemented with energy consumption in order to have the energy use of buildings, neighborhoods, city or province. This model is based on Geographical Information System with the aim to create a map in which each building (corresponding to a polygon on the Municipal Technical Map (CTC)) is identified by a specific energy demand and supply value. Figure 3 shows the flow chart of the proposed methodology.

2.3_BIM

In order to achieve a 3D city model, Building Information Modelling can extend the data richness of GIS models by providing semantic information of building components. Actually, BIM represents both the most appropriate methodology and tools to create a unique platform for the Building Lifecycle Management (BLM), which should be shared and constantly updated. In this sense, BIM for Facility Management will need to support a wide range of information requirements, integrating with multiple enterprise data systems, including Computer Aided Facility Management (CAFM), aside from GIS. Clearly, all of the data is not entered into one model or one system, therefore systems interoperability is required so that data can be communicated from upstream systems for downstream use (International Facility Management Association, 2013). For this reason, the final objectives of modelling and the outputs to be achieved must be clearly defined in the early stages of the process to make models effectively useful, considering the parties involved.

Public buildings are the focus of this BIM testing, so some of them have been analyzed and modeled as focal points of the city (i.e. municipal offices, public library, primary and secondary schools). In this context, the BIM-based digitalization project of the public buildings of the City of Turin constitutes a point of reference (Ugliotti, 2015). The methodology defined (Ugliotti et al., 2015) in this study makes replicable the process for other municipalities that want to promote intelligent actions at this time of digital transition. Within the project's purposes, it is appropriate starting from the building's survey in order to obtain data validation. In this way, the BIM model is used to represent the latest state of an existing building, including the most relevant information for the building lifecycle, adding an important value to the process. Its constant updating is required to become a real tool for simulation and planning in addition to a repository of information. The survey is aimed at verifying the "as is" documentation, cataloging thermal and lighting assets according to their type and number and getting detailed measurements of specific component such as window frames and ceilings. Autodesk Revit has been chosen for the testing for its ability to interoperate with other software through specific plug-in or overlay.

According to the main scope of the research, a common implementation of parametric models is necessary to achieve a coherent system for all buildings under study to take advantage of the BIM environment's potentialities. As it

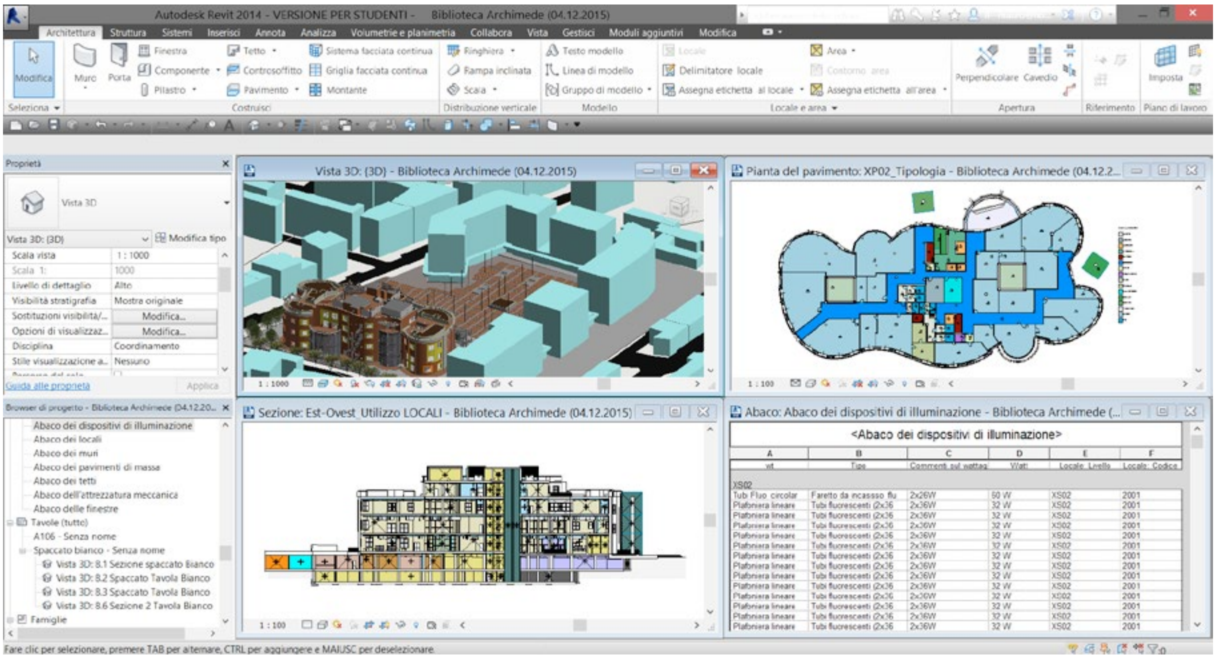


Figure 4. Building Information Model. Case study: Archimede Library, Settimo Torinese. Modelled by Maurizio Dellosta.

has been introduced before, the final purposes deeply influence this setting, so several modelling standard and additional parameters have been implemented in a Template to obtain comparable outputs and data. An accurate building envelope's characterization in terms of correct stratigraphy and transparent components' properties as well as a space and asset inventory has been pursued. According to this strategy, the BIM potential resides in the capacity to perform queries depending on specific needs by the use of scheduling for an overall knowledge of buildings' components and quantities. By an appropriate use of equations and shared parameters within Revit schedules, it is possible to extract information related to local, floor or to the whole building. They allow to list rooms for spaces management – specifying their intended use, responsible structure and occupants –, building components for refurbishment or intervention evaluation and assets for maintenance activities. With regard to energy aspect, it is interesting, for example, to derive the relationship between the opaque and transparent surface over the net/gross or heated/conditioned building surface and volume which can be extracted from in-place masses and their relative mass floors. In addition, these exhaustive inventories are automatically updated as the model suffers changes, so a univocal relation between the extracted information and the effective elements present in the model is guaranteed. This use of building data brings a great value to the Cultural Heritage's knowledge and management and it is also useful for the urban level characterization. In this way, it is possible to increase the level of information that can be used to make additional assessments of a district or a given Real Estate. Some indicators can be detected from these data, such examples the number of occupants per square meter in a specified area or the energy consumption related to lighting in an area occupied by a specific organizational unit.
Energy assessment and certification performed with Edilclima as well as facility management activities with Archibus also constitute part of this work. Several interoperability tests have been carried out in order to maximize the information exchange between parametric model and specialized analysis software in order to improve the process. However, the complexity and the high level of detail of the Revit model constitute a critical issue for energy simulation, so it is necessary to introduce simplifications to obtain a usable energy model. Despite the problems encountered, it was possible to obtain the building energy rating from the parametric model through the EC770 Revit plug-in. It represents further significant information for energy assessments at urban scale, which can be easy, collected and visualized in a GIS model.

3_BIM-GIS system integration

The creation of a 3D data model able to provide useful information both at building and city level is the main scope of the BIM-GIS systems integration. Smart cities' managers need these tools to analyse data for better decisions, anticipate problems to resolve them pro-actively and coordinate resources to operate effectively (IBM Corporation, 2015). Different users are involved in this process: from building managers to City Energy Manager and Public Administrator, as well as citizens, needing to visualize and manage data according to different purposes. Focusing on the district data set, it underlines the need to a more complete ad unified point of view. Unfortunately, data sharing between these two environments is not easy because they are characterized by different scale of investigation (architectural/urban and geographic) and different level of information. For this reason, the implementation of an urban model able to contain heterogeneous data represents one of the major challenges facing building information systems and several searches, as for example the DIMMER project (Del Giudice et al., 2014), has been developed in this field. The software environments are independent, but data need to be correlated in order to allow an integrated visualization and consultation. Numerous studies in the literature have shown the effectiveness of this combination of GIS-BIM at an urban level (Irizarrya et al., 2013; Sebastian et al. 2013; Sehrawat & Kensek 2014).

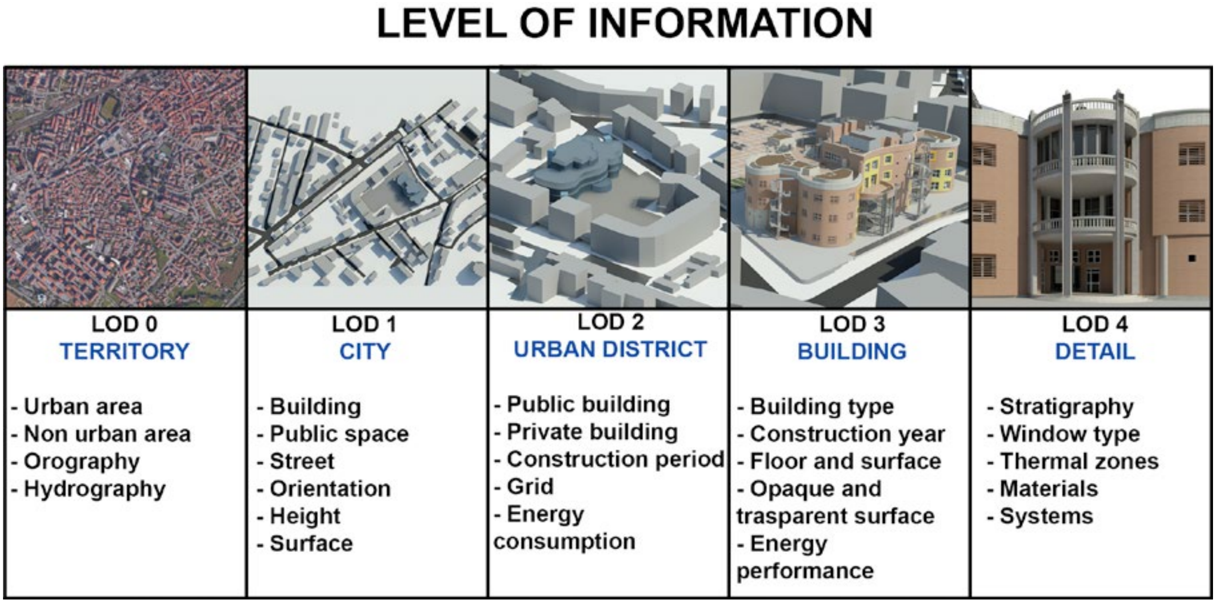


Figure 5. Level of information at different scales. Case study: Archimede Library, Settimo Torinese. Modelled by Maurizio Dellosta.

The first task is to find a balance between the different levels of detail characterizing the data sources. Currently, five LODs (Figure 5) have been taken into account for the city model within this research project, where LOD0 is the territorial level. LOD1 is represented by the three-dimensional view of the public cadastre, in which it is possible to clearly identify buildings that constitute the city and general data about location and use. Such information is most appropriate to the GIS environment to ensure better management and data visualization. LOD2 is made of a simplified building geometry at the district level, and LOD3 is focused on building representation derived from the BIM model. LOD4 introduces if necessary detailed information relating to systems and building components. Autodesk Infraworks platform is one way to connect BIM and GIS by an export / import process of the models, in which IFC and CityGML are considered the two principal standard exchange formats in the building industry. A further opportunity is to use the Revit DBLink plug-in to export the BIM database in Microsoft Access, exploiting the double graphical/tabular visualization of the model elements. In this way, it is possible to connect the BIM model's database with GIS, implementing building data. As future work, the technical approach which will be adopted for testing consists in import the models into a relational database in order to merges data coming from heterogeneous sources – BIM, GIS, Grid, Sensors network, facility management tools, improving urban data visualization and queries to more detailed overview of buildings. Finally, the use of Augmented Reality has been exploited through customized markers adding virtual contents – such as three-dimensional models, videos and images – for an attractive overview of the city's public buildings.

4_Conclusion

In this research, the DIM is presented as a tool that makes easier the visualization, managing and analysis of energy consumption and facility management data in a smart city district. At this time, the concept of BIM has become a substantial field of research in order to tackle difficulties in terms of data interoperability. Two explicit aspects of BIM were introduced during the study conducted by Isikdag et al., *facilitator of data interoperability and exchange between software applications* (Isikdag et al., 2008). Therefore, the BIM approach is extended to a district level in order to collect and visualize remotley energy usage and integrets it with real-time data (Osello, et al., 2013). Integrating BIM and GIS provide a graphical database able to improve the visual monitoring and collection of data about landscape, grid, buildings and city (Del Giudice et al., 2014). Others advantages of this combination are related to asset management like as a facilitate data collection, processing, display and mapping asset within management and budgeting tools as well as for maintenance and inspections. The model is also able to be applied on other municipalities.

As one can note, GIS approach is able to integrate individual building models linked together (BIM approach) with the energy urban network optimizing the energy demand and supply at district scale. However, DIM technology is used to integrate the supply chain process, monitoring, and control of the whole energy chain. In the next project's section, BIM and GIS methodologies will be further investigate and discuss in relation to DIM tools' development. At last, the creation of a DIM model has been also pursued to facilitate the final users' data visualization about their energy usage in a friendly way. In fact, the complexity of the data sources can be simplified according to the end user needs. Web services is one of the possible ways to link between GIS and BIM data, providing the platform as a DIM, which is capable to visualize and process the real-time district level data. Thus, it can be developed to control and monitor energy usage and production for different systems and technologies. This research, aimed at creating an effective 3D urban model of cities, represents a great opportunity for the creation of a City Living Lab, intended as a virtual hub of information necessary for planning and management in the smart city scenario.

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TOWARDS SUSTAINABLE SMART URBAN DISTRICT: A MACBETH APPROACH

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MACBETH assessment
MCDA
energy efficiency

Abstract

Lowering energy intensity and environmental impacts of buildings is becoming a priority in environmental policies in Europe, considering that cities produce about 80% of all GHG (Greenhouse gas) emissions and consume 75% of energy globally. The big challenge is to find a way to improve the energy performances of existing housing stock representing the majority of the urban fabrics in European cities.

In order to tackle these issues, the paper illustrates a multicriteria assessment model in the frame of a European project named DIMMER (District Information Modelling and Management for Energy Reduction), which aims to promote energy efficient behaviours integrating BIM (Building Information Modelling) and district level 3D models with real-time data from sensors and user feedback. The assessment model is here applied in order to rank energy development scenarios of a district in Turin (Italy) taking into account both different power generation plants.

The methodology here applied is a multi-criteria method named MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique), an Additive Value Model method requiring a non-numerical approach to build a quantitative value model.

The decision process is divided into four phases: 1) analysis of the decision problem and structuring the model using data obtained trough the DIMMER database; 2) validation and improvement of the model via a focus group with experts in the field; 3) weighting of the elements at stake; 4) analysis for the results.

The point of view of the end users is adopted in order to implement the assessment and find the most probable development scenario.

1_Introduction

Many solutions are today designed in a “green” context including reducing greenhouse gas emissions, saving energy, optimising a process with regard to sustainability criteria, enabling participation and/or reducing poverty (Hilty et al., 2013).

ICT (Information and Communication Technologies) are recognised as being key players against those tasks particularly when dealing with energy: pervasive sensors and actuators can efficiently control the energy chain (Smart Thermal/Electricity Grid). On the other side, advances on 3D modelling, visualisation and interaction technologies enable user profiling and real-time feedback to promote energy efficient behaviours.

To unlock the intrinsic potentialities of those technologies, the Politecnico di Torino started to coordinate a European project called DIMMER (District Information Modelling and Management for Energy Reduction). The DIMMER project (www.dimmer.polito.it) consists of a software system that is made of a collection of components centred on the DIMMER middleware.

The DIMMER technology is intended to be used by energy managers and public authorities to monitor district energy data as well as simulate and implement energy management policies at district level. The main focus of the DIMMER project are: 1) modelling the integration of Building Information Models (BIM) with real-time data and their extension at the district level (DIM-District Information Modelling); 2) developing middleware able to integrate different data sources: Building Information Model (BIM), System Information Model (SIM) and Geographic Information System (GIS); 3) optimising the exchange of information on ICT new platform and DBs improving interoperability; 4) visualise real-time energy related information in the building and district environment, using virtual and augmented reality.

In order to validate the DIMMER innovative system, both existing and historical public and private buildings included in urban districts are considered in two different cities: Turin (Italy) and Manchester (The United Kingdom).

Despite the undeniable and intrinsic potentialities of the ICT, it is difficult to determine whether the benefit of smart solutions will materialise under real-word conditions particularly when dealing with smart solutions for energy saving affecting users behaviour.

In order to deal with this aspect of the problem, the authors of this study decided to apply a Multicriteria Decision Analysis (MCDA) (Figueira et al., 2005; Roy and Slowinsky, 2013) to identify and analyse the most important criteria to be considered in view of a energy change in the district's scenario and, at the same time, identify the best future energy scenario for the district in exam.

The research reported in this paper is ongoing and illustrates the first assessment exercise based on a focus group about the pilot district "Crocetta" in the city of Turin. The DIST department of the Politecnico di Torino hypothesized different energy development scenarios finalised to a reduction of the energy consumption and CO_2 emissions for the district starting from the data provided by the DIMMER software.

The paper shows a simulation of a decision process involving real stakeholders. It was structured through MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) in order to discuss the decision criteria and rank the alternative energy scenarios. The reasons why the authors choose this method rather than others is explained in the next section.

After the introduction, the paper is organized as follows: section 2 is dedicated to the MACBETH methodology; section 3 briefly explain the case study and the application of the methodology; section 4 contains the conclusions and the further developments.

2_Methodological background of the evaluation method

The method used in this study is the MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique). This is a MCDA developed in the early 1990's by Bana e Costa C.A. and Vansnick J.C. (Bana e Costa and Vansnick, 1997a, 1997b, 1999; Bana e Costa et al., 2010). The MACBETH approach is based on the Additive Value Model (Figueira et al., 2005) and requires only qualitative judgements about differences of value to help an individual or a group quantify the relative attractiveness of the options.

Starting from the qualitative judgements requested to the decision maker (DM), the MACBETH method allows the construction of quantitative values model (Bana e Costa and Oliveira, 2002; Bana e Costa and Chargas, 2004;

Bana e Costa et al., 2004). This supports an interactive learning process about the problem and the elaboration of recommendations (Von Winterfeldt and Edwards, 1986) reducing the "cognitive discomfort" (Fasolo and Bana e Costa, 2009) that could arise in the DM when he/she is asked to express his/her preferences in a numerical scale.

There are theoretical researches and practical applications of the MACBETH method in different fields as, for example: evaluation of bids and measures of European structural programs (Bana e Costa et al., 2002a, 2002b); territorial planning projects and real estate market (Bana e Costa and Correa, 2000; Bana e Costa et al., 2008; Frenette et al., 2009; Méndez at al., 2014); evaluation of material suppliers (Oliveira and Lourenco, 2002); education (Cuadrado and Gutiérrez Fernández, 2013); waste management (Dhouib, 2014); energy consumption (Ertay T. et al., 2013; Marques and Neves-Silva, 2015).

The choice to apply the MACBETH method (Bana e Costa and Vansnick, 1997a, 1997b; Bana e Costa and Oliveira, 2002), among the different multicriteria techniques available, is due to a number of reasons. First the MACBETH is a simple and understandable methodology even by those who are not experts in the decision process. Second, its technical parameters have a clear and easily explicable substantive interpretation allowing the processing of difficult problem of relative importance of criteria in a precise way. Third, the results that the MACBETH is expected to bring are lists of k-best actions expressed in numerical values to be analysed further by the people involved. Final, the M-MACBETH software involved (www.m-macbeth.com) and the interaction protocol are compatible with the way of reasoning of the inquired people and with their meaning of useful results.

The MACBETH methodology can be divided into three main application phases: model structuring, model evaluating and analysing the results.

Model Structuring: During the structuring phase, the options to be evaluated and their performances as well as the values of concern need to be identified. The MACBETH approach permits the evaluation of different options or alternatives (understood as any potential course of actions) against multiple criteria. Any option is, in and itself, a mean to achieve an end. Good decision-making therefore, requires deep thought about what one wants to achieve through which the values that are of concern with the specific decision context will emerge. Some of these may be broadly defined while others may be more specific (Bana e Costa, 2001). The specific values of the evaluation are called "criteria nodes" while the broadly defined values, or the elements for which only vague information are available, are called "non-criteria nodes". Structuring these values in the form of a tree, generally referred to as a "value tree", offers an organised visual overview of the various concerns at hand (Bana e Costa and Vansnick, 1997a).

Model evaluating: After structured the model, MACBETH involves a series of pairwise comparisons, where the DM is asked to specify the difference of attractiveness between all of the alternatives with respect to the criteria. In order to fill in the pairwise comparison matrices, the following semantic categories are used: Extreme, Very strong, Strong, Moderate, Weak, Very Weak, No (no differences between the elements).

The options can be scored in two ways: directly comparing the options two at a time (direct comparison) or indirectly through the use of a value function built by comparing pre-defined performance levels rather than the options themselves (indirect comparison). In this second scoring mode a value function will be used to convert any option's performance on the criterion into a numerical score (Figueira et al., 2005).
As the judgements are entered into the matrices, the MACBETH uses an algorithm based on linear programming (Bana e Costa et al., 2010), in order to verify their consistency. After that, the performance of each option on each criterion is transformed into a value score that measures the relative attractiveness of the options on that criterion (Sanchez-Lopez et al., 2012).

Analysing the results: Once the model has been structured and filled in, the MACBETH method provides very clear results in the form of ranking allowing identify the attractiveness of the problem's criteria and alternatives. During this phase, extensive analyses can be performed to provide a deep understanding of the problem, contributing to attain a requisite evaluation model: the sensitivity analysis can be performed in order to visualize the extend to which the model's recommendation would change as a result of the change made to the weight of the criteria; the robustness analysis can be performed in order to explore the extend to which conclusions can be drawn given varying amount of imprecise or uncertain information (Bana e Costa et al., 2004).

3_The case study

The "Crocetta" district in Turin (Italy) is characterised by continuous curtain blocks shaped by large lots with fenced yard. The area has both public and private buildings that allow studies in order to optimise opportunities on energy saving due to the building usage by people. DIMMER collects data about the thermal energy consumption for all the pilot buildings connected to district-heating (around 60) with non-invasive sensors, but some buildings have been selected as representative of the district to test the ICT invasive sensors provided by the DIMMER project and be thoroughly investigate, are 4 schools, 1 university residence, 1 office and 4 private buildings. These buildings are different for orientation, dimension, use, technology, materials and construction period. Moreover, the possibility to have into the district schools for each levels of education, will allow researchers to test the communication system that will be developed with the DIMMER project with different students in order to improve their awareness on energy saving using targeted solutions and technologies.
Since the DIMMER project and the research presented are on going, some information about the problem in exam still need to be collected. For this, during this first focus group, we considered not the entire district but 20 buildings for a total amount of 502 show flats. 10 buildings are currently connected to the district-heating while 10 buildings are not connected. The assessment focus group presented in this paper is the first of a series of focus group that will be organised under the DIMMER project during the year 2016 with the aim of finding the best energy scenario for the district "Crocetta", and developing more general considerations about the heating systems at district level.

The objectives of the assessment were therefore many: 1) to talk over about the considered assessment criteria; 2) to identify any additional criteria that should be considered in order to implement the model for future focus group; 3) to identify the best energy scenario for the district in exam; 4) to test the MACBETH method for the management of a decision process in the energy planning field.

3.1_Model structuring

Three alternative scenarios were developed by the researchers of the DIST Department of the Politecnico di Torino (Table 1) basing on literature review about district energy scenarios comparison (Paiho et al., 2013, 2014) and according to the DIMMER project's feedbacks.

The alternative scenarios have been compared through the use of the MACBETH method starting from the following assumption: in an hypothetical horizon of 15 years, due to obsolesce and/or to emission regulation on heating boilers, all the buildings not currently connected to the district-heating or without a condensing boiler will have to retrain the heat generation plant (Piedmont Regional law 13/2007).

It's important to underline that the three alternative scenarios proposed are simplifications of possible energy development perspectives. The alternative scenarios' intent is to be revealing and provocative in order to stimulate the discussion during the focus group.

Table 1. Alternative energy scenarios.

Energy scenario		Description
1	Max District Heating	Huge development of the district-heating. The 80% of the buildings will be connected while the remaining 20% of the buildings will install a condensing boiler.
2	Min District heating	The district-heating is locked to the current situation. 50% of the buildings will remain connected to the district-heating while the remaining 50% of the buildings will install a condensing boiler (cheapest alternative).
3	Heating and pellet	The district-heating is locked to the current situation. Some users that are connected to the district-heating will change the boilers choosing a condensing or pellet boiler. The users not currently connected to the district-heating will install a condensing boiler or pellet boiler (depending on their annual consumption).

In order to structure the model according to the MACBETH methodology, 4 criteria nodes were identified among the information presented in Table 2: **Average investment costs**, **Average maintenance and heating costs** (together considered), **Reduction of the CO_2 emissions** and **Resilience of the energy system**.

Data analysed was provided by DIMMER platform. The data refers to buildings as block of apartments heated by a centralized heating system (generally situated in the basement). Some of the centralized systems are connected to the district-heating network, while others have fuel boilers. Building thermal energy consumption, building heated volume and heating station thermal power are available in the DIMMER database. Costs related to new installation, fuel and maintenance were calculated with the linear regression mode based on data provided by heating System Company based in

DATA	Description	Measure	Current	Scenario 1	Scenario 2	Scenario 3
N° of flats	Number of flats that retain the original heating plant	Number	-	**225**	**225**	**317**
Average investment cost per year and one flat	Investment costs needed to modify the previous heat generating plant	Euro	-	**€ 722**	**€ 1.249**	**€ 2.420**
Average heating cost per year and one flat	Cost related to the generation of thermal energy	Euro	-	**€ 531,39**	**€ 441,22**	**€ 402,32**
Average maintenance cost per year and one flat	Cost related to the maintenance of the heat generation plant	Euro	€ 99,40	**€ 76,41**	**€ 79.81**	**€ 90,54**
Reduction of the CO_2 emissions	Reduction of the pollutant emissions	Percentage	-	**2%**	**6%**	**21%**
Resilience of the energy system	Ability of soak up economy and physical shocks of the energy system	Ordinal scale	-	**Low**	**Medium/ Low**	**Medium**
Percentages of fuel use for each scenario						
District-heating	Percentage of building connected to the district-heating	Percentage	49%	**71%**	**49%**	**27%**
Natural Gas	Percentage of buildings using natural gas as fuel	Percentage	46%	**29%**	**51%**	**50%**
Diesel	Percentage of the buildings using diesel as fuel	Percentage	5%	**0**	**0**	**0**
Pellets	Percentage of the buildings using pellet as fuel	Percentage	0	**0**	**0**	**23%**

Table 2. Scenarios information.

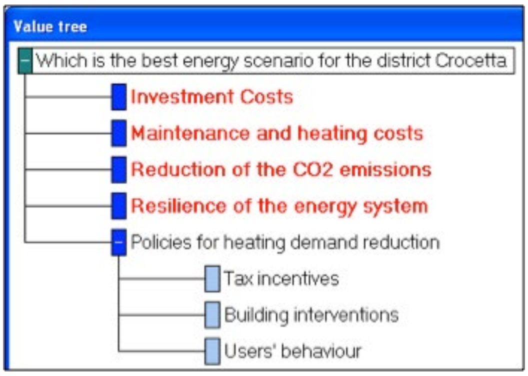


Figure 1. Value tree of the MACBETH model.

Turin. Specifically installation cost was calculated on a basis of 40 thermal station refurbished in the years 2013-2015. Emission data were calculated based on standard data provided by Piedmont Region (46-11968). The criteria nodes and the scenarios were discussed during the focus group. The DMs involved had different backgrounds. They were: 2 representatives of the Turin Builders' Association, 1 real estate developer, 1 designer, 1 representatives of the CSI Piedmont (Consortium for the information system), 1 representative of the Piedmont Region, 1 representative of the metropolitan city of Turin, 1 designer of energy plants and 1 academic expert in energy.

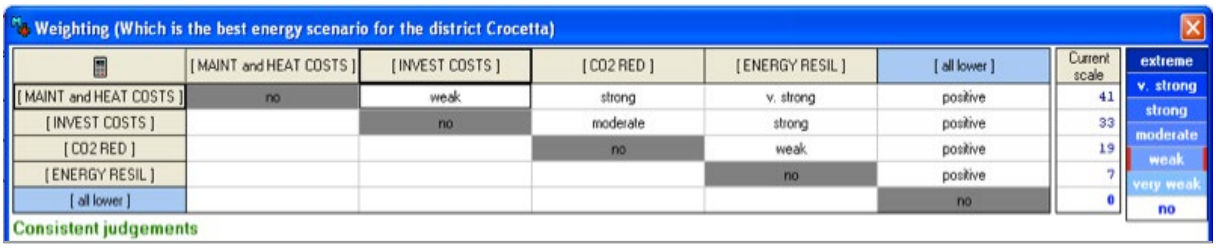
The value tree of the MACBETH model is presented in Figure 1.

Moreover, as a consequence of the focus group discussion, three *non-criteria nodes* related to the policies for heating demand reduction (i.e. tax incentives, buildings interventions and users' behaviour) were added to the value tree, in order to considered them as *criteria nodes* in future assessments.

3.2_Model evaluating

After structuring the model, a free discussion among the stakeholders was finalised in setting up a ranking of assessment criteria in order to identify the most important criterion to be considered in the energy transformation at stake.

All the stakeholders' opinions were collected during the focus group and then aggregated following the "majority method": we gave the preference to the criterion that had the highest number of judgements and we determined then a mathematical mean in order to find the differences of attractiveness (Lami et al., 2014; Lami, 2014) (Figure 2).

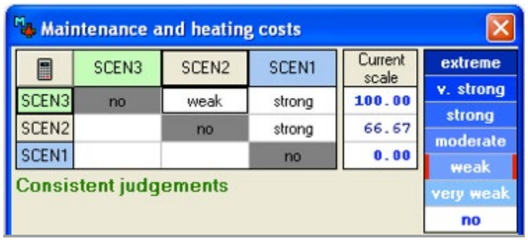


Weighting (Which is the best energy scenario for the district Crocetta)

	[MAINT and HEAT COSTS]	[INVEST COSTS]	[CO2 RED]	[ENERGY RESIL]	[all lower]	Current scale
[MAINT and HEAT COSTS]	no	weak	strong	v. strong	positive	41
[INVEST COSTS]		no	moderate	strong	positive	33
[CO2 RED]			no	weak	positive	19
[ENERGY RESIL]				no	positive	7
[all lower]					no	0

Figure 2. Criteria judgements.

As it is showed in Figure 2, the most important assessment criterion turned out to be **Average maintenance and heating costs** (41%) followed by **Investment costs** (33%), **Reduction of the CO_2 emissions** (19%) and **Resilience of the energy system** (7%). Therefore, following the reasoning of the stakeholders, the economic aspects of the problem are the most important for the end users facing this energy change while the resilience of the energy system is not fundamental for the decision process because there is currently not a big differences of resilience capacity among the three scenarios. This result reflects a big actual problem about a society change toward energy behaviours less pollutant. All the participants of the focus group working in the energy sector underlined that the economic aspect is still overwhelming compared to the environmental issues.



Maintenance and heating costs

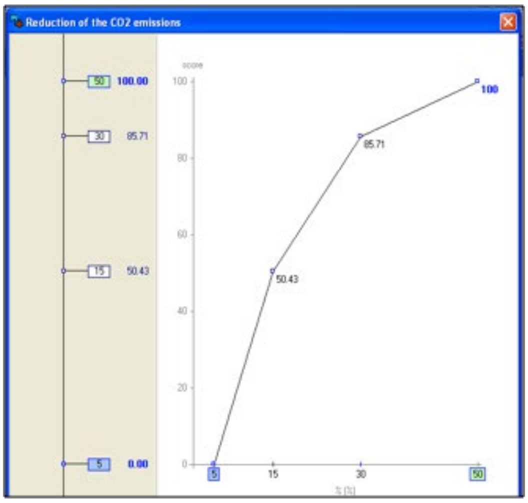
	SCEN3	SCEN2	SCEN1	Current scale
SCEN3	no	weak	strong	100.00
SCEN2		no	strong	66.67
SCEN1			no	0.00

Figure 3. Maintenance and heating costs judgements.

Going deeper in the MACBETH model, the stakeholders were asked to answer to the pairwise comparisons related to each single assessment criterion. In order to clarify the process, we report two pairwise comparison matrices: the Maintenance and heating costs judgements (direct comparison - Figure 3) and the Reduction of CO_2 emissions judgements (indirect comparison - Figure 4).

According to scenarios' information in table C, Scenario 3 has the best performance in terms of Maintenance and heating costs (493,46 €) followed by Scenario 2 (521,03 €) and Scenario 1 (607,8 €). Therefore the stakeholders judged that the difference of attractiveness between scenario 3 and Scenario 2 is weak while Scenario 2 is strongly preferred to Scenario 1 one as it is showed in Figure 3.

For the criterion **Reduction of the CO_2 emissions** (Figure 4) we decided to apply an indirect comparison by comparing pre-defined performance levels (Table 2) according to the MACBETH methodology (Bana e Costa, 2001).



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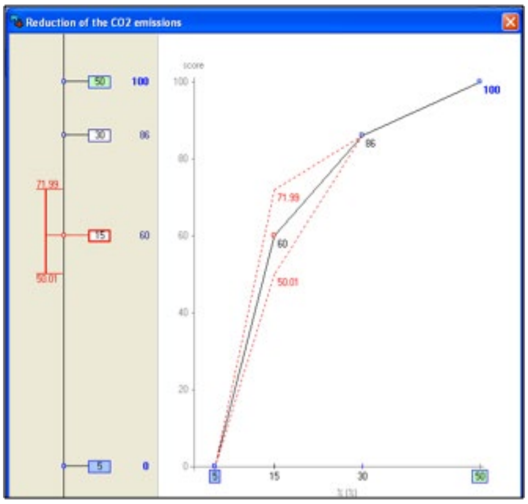

b

Figure 4. Reduction of the CO_2 emissions judgements.

In order to come to a sensible result, first the stakeholders identified an acceptability range of values for the reduction of the CO_2 emissions: between 20% and 30%. With this in mind, they answered to the pairwise comparisons stating that: 1) a 5% of CO_2 reduction is not acceptable because no one would operate a choice basing on this very low value; 2) a 15% of CO_2 reduction is considered interesting and therefore the differences of attractiveness between 5% and 15% is very strong; 3) a 30% of CO_2 reduction is considered the highest reachable level and the differences of attractiveness between 15% and 30% is strong; 4) a 50% of CO_2 reduction is obviously the best possible performance but it is considered as not reachable in the fixed temporal horizon of 15 years.

Once all the judgements have been inserted in the M-MACBETH software, the stakeholders decided to highlight a distance of 10 scores between the 5%

and the 15% performance (Figure 4b). The M-MACBETH software provides in fact a visual representation in form of thermometer of the distance between the elements in terms of attractiveness. This is to facilitate the stakeholders in understanding and modify their answers basing on the provided results. The value scores can be therefore changed while keeping fixed the remaining scores of other options and maintaining the compatibility with the matrix of judgements (Bana e Costa, 2010). Once answered all the pairwise comparisons required have been filled in, the overall results of the model were calculated (Figure 5).

Figure 5. Overall results.

Table of scores

Options	Overall	COST-INVEST	COST-RISCMANUT	RID CO2	RES
SCEN1	29.74	100.00	0.00	-17.14	0.00
SCEN2	52.89	60.00	66.67	5.71	66.67
SCEN3	61.03	0.00	100.00	68.57	100.00
[all upper]	100.00	100.00	100.00	100.00	100.00
[all lower]	0.00	0.00	0.00	0.00	0.00
Weights :		0.3300	0.4100	0.1900	0.0700

4_Discussion of the results and final remarks

This paper has presented a multicriteria application in order to structure a decision related to urban district energy development scenarios. The method used for this exercise is MACBETH approach because it allows interaction among stakeholders in order to quantifying value judgments about the elements of a finite set.

The assessment exercise was based on a focus group. As one can see from Figure 5, according to the answers provided during the focus group, the best alternative energy scenario for the district “Crocetta” turned out to be the Scenario 3 (61,03%) in a perspective of reducing the maintenance and heating costs and the CO_2 emissions by using clean fuels (i.e. pellet and biomass). Scenario 2 is also considered as an interesting scenario (52,09%) because it is economically affordable even if it does not reach the requested performances of CO_2 reduction. On the contrary, Scenario 1 turned out to be not good (29,74%) mainly due to the high heating costs and the very low possibility of reducing CO_2 emissions. Here the two “souls” of the participants emerge: the business operators emphasize the need for the economic viability of the investment, while the representatives of the public authorities advocate a reduction of the CO_2 emissions. This result is a sign of good balance with which the focus group was organised, and of the challenge in the decision-making process at the same time. This is to reconcile aspects that are currently antithetical.

It is evident that, in Italy, big changes in energy infrastructure can only take place if required by regulations or if effectively inserted in a logic of commercial advantage.

This application represents the first of a series of subsequent applications, which will be used to finalise the results. In fact, the sensitivity and robustness analyses of the results will be performed and new criteria will be added as suggested during the focus group, as the policies for heating demand reduction, will be considered.

Moreover, we currently consider the benefits arising from specific policies simply deriving them from the addiction of single buildings data. This critical aspect will be solved in further applications deriving the benefits also as possible synergic effects at a district level.

5_Acknowledgement

This study has been developed in the framework of the DIMMER- "District Information Modeling and Management for Energy Reduction" project (2013-2016). This project has received funding from the European Union's Seventh Programme for Research, Technological Development and Demonstration under Grant Agreement No. 609084.
The authors wish to thank all to the stakeholders involved in the focus group reported in this paper.

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Abstract

In sustainable development of city structures, increasing power consumption requires maintaining power grid safety and reliability with less mismatching between electricity generation and demand. Power grid fluctuations in both power demand and generation induce an effort to supplementary setting on conventional production units and efforts to maintain grid stability. Hence, nowadays with the trend towards more complex, flexible and dynamic systems as well the higher penetration of distributed and decentralized renewable energy systems, the issue of peak reduction of demand/generation mismatch has gained importance. Shopping malls, often centrally located in urban districts, have high energy savings and carbon emissions reduction potential due to their large electrical and thermal loads. At the same time, shopping malls cover important surface areas and are reference points in urban districts for citizens, with possibilities to provide services to both the grids and the community.

This paper studies the interaction between shopping centres and the electrical grids to which they are connected for 3 different locations in Europe with the objective to identify key aspects which allow improving the current interaction and identifying the capacities that these types of buildings could give as suppliers/providers of services to the local energy grid. The results will help to optimize renewable energy production integrated in shopping centres by being able to optimize self-consumption, reducing the energy need to generate and deliver additional electricity and allow the participation of the end-users in the management of energy with grid providers.

INTERACTIONS OF SHOPPING CENTRES WITH LOCAL ENERGY GRIDS

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shopping centres

1_Introduction

In sustainable development of city structures, increasing power consumption requires maintaining power grid safety and reliability with less mismatching between electricity generation and demand (SERN, 2013). Power grid fluctuations in both power demand and generation induce an effort to supplementary setting on conventional production units and efforts to maintain grid stability. Hence, nowadays with the trend towards more complex, flexible and dynamic systems as well the higher penetration of distributed and centralized renewable energy systems, the issue of peak reduction of demand/generation mismatch has gained importance (Haunstrup, 2013). Shopping malls have high energy savings and carbon emissions reduction potential due to their large electrical and thermal loads. At the same time, shopping malls cover important surface areas and are a reference point for citizens, with possibilities to provide services to both the grids and the community (Sanchez-Jimenez, 2003; OED, 2012).

2_Objectives

New concepts in the current energy grid have emerged in order to solve grid problems by increasing the control and awareness over the consumed energy (Adinolfi et al., 2013; Dam et al., 2008; Yeung, 2007). This paper studies the interaction between the shopping centres and the electrical grids to which they are connected with the objective to identify key aspects which allow improving the current interaction and identifying the capacities that these types of buildings could give as suppliers/providers of services to the local energy grid. The results will allow the participation of the end-users in the management of energy with grid providers.

3_Methodology

The methodology involves firstly a characterization of shopping centres with respect to load profiles, climate, urban and energy contexts, among other aspects which condition the interaction between building and grid.
Methodology followed consists of four steps:

1. Definition of parameters which characterize the building, the building context and the interaction of building with grid.
   - The characterization of the reference buildings and the building context is based mainly on the parameters defined in (Antolin et al. 2015). Most significant parameters have been included in a questionnaire delivered to the reference buildings owners/managers. This questionnaire intended to compile the relevant information from building (size, type, schedule and consumption profile), energy supply characteristics, included the grid capacity and evaluate the possibility for connection modification. The questions included were analyzed with detail in order to be able to get suitable information from the minimum number of points in order to persuade owners/managers in its reply.
   - For the characterization of building-grid interaction, it was considered indicators described in (Salom et al., 2014). In the case of Valladolid reference shopping centre, an energy grid analyzer was also utilized for measuring the quality of supply electricity fed by the grid to the building. This building is located in an urban context, the city centre, with likely high degree of grid saturation; therefore, it is assumed that this building represents the worst conditions, while the other reference buildings could have better conditions.
2. Characterization of shopping centres by the analysis of the data compiled in questionnaires.
3. Definition of the potential of shopping centres as energy service and identification of the best solutions for each shopping centre. Once the diagnosis of shopping centres is done, it can identify constrains and potentials of buildings for being exploited as energy service. Then, it is possible to propose a set of solutions according to the previous premises by each shopping centre (on site RES, Energy Storage, Peak Shaving and Energy Saving), see also (Angel et al., 2011; Jelle et al., 2012; Cucchiella, 2012, ITM 2011; ITM, 2014).
4. Evaluation of the impact that energy solutions would produce on the local grid in case they were applied in shopping centres through Load Match and Grid Interaction (LMGI) indexes. The procedure for this analysis consists of:
   - Generation of generic energy profiles for each reference building.
     – Generic energy profiles of the current situation of the reference shopping centres using EnergyPlus were created based on simplified

models of commercial building and locations (three types of climatic conditions/weather files) (DOE, 2012). Since the DOE reference building depends also on the US climate zone, we chose the reference building related to the US climate zone most similar to the one where it is located. (i.e. London climate is similar to US climate zone 5B, etc..). This just leads to different wall constructions, design days and electricity source and emission factors. Subsequently, typical days for three different seasons (summer, winter and middle-season) were generated. The profile is adjusted to the location of reference buildings once it is introduced the climate characteristics of the places where they are located. Since, profiles are shown in Wh/m^2, they are adapted to the real surface of the supermarket and retail areas; these represented the baseline scenario.

- Evaluation of the energy generation and energy saving potential for the set of solutions proposed by each shopping centre.
  - Energy generation for RES (Renewable Energy Systems) solutions (PV and wind) is evaluated with TRNSYS (TRNSYS, 2011). For the capacity of PV, it was taken into account the available surface of each building, the climate and own restrictions of the building (shadow effect for surrounding building). For the case of the wind energy, it has estimated the production of energy taking into account a size of the turbine suitable to each building, the climate and the own restrictions of the building (e.g. location in urban context). Energy generation profile associated to the cogeneration is evaluated with EnergyPlus, assuming a 30% of efficiency based on thermal efficiency (DOE, 2012).
  - The energy profile of buildings associated with the incorporation of efficient solutions (HVAC, Lighting, Envelope and Refrigeration) was calculated with EnergyPlus in line with the most ambitious settings defined in (Haase et al. 2015).
- Calculation of Load Match and Grid Interaction indexes (LMGI) for the baseline and the solutions with RES alone and with RES plus one of the energy efficiency measures at the time.

4_Results

With the information collected and analyzed, it was possible to identify the potential as possible improvement actions in the interaction between the buildings and the grid, with solutions divided by on site RES, Cogeneration, Energy Storage, Peak shaving and Energy saving solutions. With the information available it has been possible to calculate the most relevant KPIs identified for the solutions proposed trying to understand how different solutions influence in the interaction between the shopping centres and the electrical grid.

The selection of solutions to provide services to the grid (e.g., increase matching during lack of electricity or use electricity during time of excess) is based on the characterization of building (available surface, energy consumption share and energy profile), environment context (climate, normative), grid capacity (current level of saturation and generation profile) and quality (non-existence of interferences in the proper operation of the system of energy supply) in order to detect the potential of building but also to note if the expansion of the capacity of the grid and especially to the use of renewable energies can produce stress for the grid.

Below is a list of potential solutions to provide services to the grid divided in five categories: on-site RES, Energy Storage, Peak shaving of demand curve and Energy saving solutions.

Based on the assessment of the context, the demand and the generation profiles, potential improvements of reference shopping centres are identified below.

4.1_Results for reference shopping centre in Valladolid

- The electricity demand of the Valladolid shopping centre is mainly due to the lighting, HVAC systems (radiant floor fed by air/water heat pumps) and the energy consumption of the refrigerators used for the conservation of the products. This gives an idea in where is possible to act to reduce the electricity consumption of the shopping centre.
- The demand profile shows a clear correlated character with the timetable during the market working day. Thus, the highest values are produced from 9:00 to 16:00, although there is a minimum consumption mainly due to the refrigerators outside of working hours.
- The cooling systems are old and undersized because, following the air temperature analysis and the users and clients comments, the comfort levels are not reached a lot of times. Furthermore, the low air-tightness, owing to building status, causes elevated energy consumption and it is a constraint for achieving the comfort conditions.
- Existing lighting systems are old and non-efficient in contrast to the modern lamps and luminaires in the marketplace.
- There is no energy management system for programming the control strategies so as to deal with the energy management.
- Results obtained with the grid analyzer reveal that:
  - The results of the analysis of the main electrical parameters in the supply indicate the lack of network quality problems, during the metering period.
  - Elevated reactive energy consumption has been detected.. This penalizes into the bills from the supplier.
  - Great values in the harmonics 5 and 7 have been detected due to non-linear loads (luminaires, fans…). This could influence the quality of the grid in terms of disturbances.
- There are no renewable systems for the electricity generation connected to the distribution grid of the market which affect regulations with regard to the renewable installation typical to each distribution line.
- The urban environment and the presence of buildings in the surroundings limit the installation of the photovoltaic and wind turbines. Besides that, the historical character of the building is a determinant too. However, high levels of radiation make solar panels a potential solution for this building.

4.1.1_Load matching and grid interaction

Table 1 shows the load matching and grid interaction based on the potential improvements for the Valladolid reference shopping centre.

Table 1. Load matching and grid interaction for Valladolid (BC: Base case; PV: Photovoltaic; WP: Wind Power; LG: Lighting; EN: Envelope).

		base case (BC)			Reduced lighting (LG)	Envelope improvements (EN)
		+PV	+WP	+PV+WP	+PV	+PV
LMavg	winter	6%	2%	9%	12%	7%
	mid-season	13%	2%	15%	24%	14%
	summer	19%	2%	20%	32%	20%
GI	winter	30%	34%	31%	21%	31%
	mid-season	24%	34%	24%	25%	23%
	summer	30%	34%	30%	20%	28%

4.1.2_Grid Interaction improvements

Table 2 shows the Grid Interaction improvements compared to the base case in Valladolid.

Table 2. Grid interaction improvements for Valladolid.

Season	BC + PV	BC + WP	BC + LG	BC + EN	BC+ PV + WP	BC + LG + PV	BC + EN + PV
Winter	3%	0%	7%	0%	3%	12%	3%
Mid-season	11%	0%	6%	0%	11%	9%	11%
Summer	4%	0%	5%	0%	4%	13%	6%

4.2_Results for reference shopping centre in Trondheim

- The electricity demand of shopping malls in Trondheim is mainly due to lighting and appliances and HVAC. This gives an idea in where the potential lies to reduce the electricity consumption of the shopping centre.
- The demand profile shows a clear correlated character with the timetable during the working hours. Thus, the highest values are produced from 9:00 to 16:00, although there is a minimum consumption mainly due to lighting and appliances outside working hours.
- There are no renewable systems for the electricity generation connected to the distribution grid of the market which affect regulations with regard to the renewable installation typical to each distribution line.
- The urban environment and the presence of mainly low-rise buildings in the surroundings favour the installation of the photovoltaic and possibly wind turbines.

4.2.1_Load matching and grid interaction

Table 3 shows the load matching and grid interaction based on the potential improvements for the Trondheim reference shopping centre.

Table 3. Load matching and grid interaction for Trondheim (CHP: Combined Heat and Power).

		base case (BC)			Reduced lighting (LG)		Envelope improvements (EN)		HVAC improvements	
		+PV	+WP	+CHP	+PV	+PV+WP	+PV	+PV+WP	+PV	+PV+WP
LMavg	winter	0.7%	14.7%	138.5%	1.5%	24.5%	0.7%	17.0%	0.7%	15.3%
	Mid-season	5.3%	12.1%	9.3%	11.0%	46.9%	12.9%	25.5%	12.3%	24.2%
	summer	12.6%	13.4%	66.2%	26.0%	39.9%	5.5%	19.2%	5.3%	18.8%
GI	winter	39.3%	40.9%	57.6%	38.2%	40.9%	39.6%	40.9%	39.3%	40.6%
	Mid-season	40.0%	41.3%	45.3%	37.6%	39.3%	40.0%	40.8%	40.0%	40.8%
	summer	40.5%	41.6%	41.7%	37.9%	39.8%	40.3%	41.4%	40.6%	41.3%

4.2.2_Grid Interaction improvements

Table 4 shows the Grid Interaction improvements compared to the base case in Trondheim.

Table 4. Grid interaction improvements for Trondheim.

Season	BC + PV	BC + WP	BC + LG	BC + EN	BC + HVAC	BC + PV + WP	BC + CHP	BC + LG + PV	BC + LG + PV + WP	BC + EN + PV	BC + EN + PV + WP	BC + HVAC + PV	BC + HVAC + PV + WP
Winter	0.4%	-1.2%	0.9%	-0.3%	0.0%	-0.9%	-17.9%	1.6%	-1.2%	0.1%	-1.2%	0.4%	-0.9%
Mid-season	0.5%	-0.7%	-0.3%	0.0%	0.0%	-0.3%	-4.8%	2.9%	1.2%	0.5%	-0.3%	0.5%	-0.3%
Summer	0.2%	-0.9%	-0.9%	0.1%	-0.1%	-0.9%	-1.1%	2.7%	0.8%	0.3%	-0.7%	0.1%	-0.7%

4.3_Results for reference shopping centre in Catania

- The energy consumption at the Catania reference shopping centre is dominated by the lighting that accounts for 41% of the buildings predicted consumption.
- Following lighting, the consumption is equally distributed between refrigeration and HVAC.
- All these services, even lighting, have greater consumptions in the summer months.
- The electricity demand profiles for each month indicates correlation with season as well as opening hours of the building.
  - Daily: the consumption peaks are reached during the central hours of the days, toward the early afternoon (i.e., 2pm) during the winter months and in the later afternoon (4pm) during the summer months. The summer peak is associated with the peak in cooling and refrigeration needs.
  - Monthly. There is a strong correlation with the month of the year. During the summer months the consumptions are approximately 20% higher due mainly to the elevated electricity cooling need. The months with the highest and lowest consumptions are July and December.
- Assessing the present building situation we noticed
  - Envelope: structural elements could be improved including wall and window transmittance, exploitation of daylight, use of natural/hybrid ventilation
  - Active:
    - BMS to control and manage conditions (e.g., setting, presence, lux level) and energy fluxes (including improved efficiencies in the heat recovery system)
    - Improved refrigeration systems
    - Efficient artificial lighting systems
  - Load management: management of loads and generation matching (also with batteries) to increase self-consumption and take advantage of favorable tariffs
  - RES: limited exploitation of on-site RES that should be considered (e.g., PV, solar thermal collectors or min-wind turbine)

4.3.1_Load matching and grid interaction

Table 5 shows the load matching and grid interaction based on the potential improvements for the Catania reference shopping centre.

		base case (BC)		Reduce lighting (LG)	Envelope improvement (EN)	HVAC improvement	Refrigeration improvement (RF)
		+PV	+CHP	+PV	+PV	+PV	+PV
LMavg	winter	9,7%	20,9%	19,7%	10,2%	9,7%	10,4%
	mid-season	14,5%	6,0%	27,4%	15,4%	14,8%	15,6%
	summer	20,2%	0,5%	36,4%	22,0%	21,8%	21,5%
GI	winter	29,7%	39,3%	24,2%	29,4%	29,7%	30,5%
	mid-season	27,7%	35,9%	24,8%	26,7%	27,4%	28,7%
	summer	29,4%	36,6%	28,6%	28,0%	28,0%	30,3%

Table 5. Load matching and grid interaction for Catania (RF: Refrigeration).

4.3.2_Grid Interaction improvements compared to the base case

Table 6 shows the Grid Interaction improvements compared to the base case in Catania.

Season	BC + PV	BC + CHP	BC + LG	BC + EN	BC + HVAC	BC + RF	BC + LG + PV	BC + EN + PV	BC + HVAC + PV	BC + RF + PV
Winter	6.3%	-3.3%	5.9%	0.1%	0.0%	-1.2%	11.8%	6.6%	6.3%	5.5%
Mid-season	7.2%	-1.0%	4.6%	0.1%	-0.3%	-1.3%	10.2%	8.3%	7.6%	6.2%
Summer	7.1%	-0.1%	3.4%	0.4%	0.2%	-0.9%	7.8%	8.4%	8.5%	6.2%

Table 6. Grid interaction improvements for Catania.

Load Match	BC + PV	BC + WP	BC + CHP	BC + LG	BC+ EN	BC + HVAC	BC + RF
Valladolid reference shopping centre	12,60%	2,00%		10,07%	1,06%		
Trondheim reference shopping centre	6,20%	13,40%	71,33%	6,63%	0,17%	-0,10%	
Catania reference shopping centre	15,40%		9,13%	12,43%	1,46%	0,03%	0,43%

Table 7. Load match for all 3 reference buildings.

Table 7 summarized the solutions proposed for each building reflecting the degree of improvement in the interaction between the shopping centres and the electrical grid with different colours. Then and depending on the degree of improvement, is possible to extract a general idea of the most feasible solutions to be applied in a general shopping centre.

In this table, and using different colors, the idea is to identify which of the solutions based on the KPIs calculated are more efficient in each specific case of each building taking into account all information available. The color is going to indicate if the solution is more or less effective to each shopping centre. In the legend below the table, is possible to see which color match with the degree of effectiveness (From a large to a low improvement) of the specific solution (PV, Wind “WP”, Cogeneration “CHP”, Lighting improvements “LG”, Envelope improvements “EN”, HVAC improvements, Refrigeration improvements “RF”).

Table 8. Grid interaction improvements for all 3 reference buildings.

GI improvement	BC + PV	BC + WP	BC + CHP	BC + LG	BC+ EN	BC + HVAC	BC + RF
Valladolid reference shopping centre	6,00%	0,00%		6,00%	0,00%		
Trondheim reference shopping centre	0,37%	0,93%	7,93%	-0,10%	-0,67%	-0,03%	
Catania reference shopping centre	6,87%		1,47%	4,63%	0,10%	-0,03%	-3,40%

As general idea from this table and following the analysis developed for each of the shopping centres previously, is possible to conclude that for most of the shopping centres due to their location (mainly at the outskirts and without many elements like buildings surrounding them), their availability of surface suitable to install generation systems and their suitable weather conditions (exposure to solar radiation and/or wind) it would be a good idea to study the possibility to integrate (or increase in case already installed) on site RES such as PV or wind power in order to produce their own electricity (self-consumption) and thus decrease the electricity consumption from the grid or even if possible to pour a surplus of electricity to the grid with the possibility to get some economic benefit. It is also important to remark that these RES systems also need a resistant structure to be integrated.

5_Conclusions

After studying 3 reference shopping centres throughout Europe it was possible to verify that there is a significant potential for improvement in the interaction between the centres and the power grid. Moreover, key aspects which allow improvements of the current interaction and the capacities that these types of buildings could give as suppliers/providers of services to the grid were identified and quantified.

- The replacement of low efficiency, old or bad dimensioned components, such as lighting or HVAC systems, allow to improve the energy efficiency of the building, in this way there is a great potential of improvement in terms of electrical reduction.
- This is also possible through the improvement of the enclosures reducing the thermal losses and thus the electrical consumption of HVAC systems and through control and management systems which allow to manage the demand in each period of time optimizing the way in which the shopping centre consumes/distributes the electricity, all these measures allow to reduce the electrical consumption of the shopping centre in terms of lighting, heating, cooling, etc.
- Other alternatives such as the energy storage allow to store energy in case a surplus of energy in renewables energies or when the grid is in "valley period" with low electricity demand and then use it in periods when is needed by the shopping centre itself or by injecting it back to the grid in peak periods.
- With the integration of renewables is possible to reduce the energy consumption and thus the electrical demand from the grid to which the shopping centre is connected through self-consumption.
- Cogeneration systems are also very useful in terms of self-consumption and reduction of demand from the grid, producing at the same time electricity and thermal energy which allow also to decrease the electrical consumption in case of electrical HVAC systems.

The results will help to optimize solar energy production integrated in shopping centres, by being able to optimize self-consumption, reducing the energy need to generate and deliver additional electricity through while also being able to benefit from injecting the surplus of energy into the grid. Additionally, the match between production and demand could be improved by modifying some of the flexible demand profiles and using excess electricity for additional services (e.g., e-vehicle charging station or hydrogen production) and in general exploiting times of low (i.e., overproduction) electricity prices. Therefore, shopping centres have high potential in contributing to the solution and assisting in managing the issue that have arose regarding RES integration, energy management and grid support.

6_Acknowledgements

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Abstract

There is no doubt we need to start a process of transformation to prevent urban systems moving into an undesirable state from which it is impossible to recover. The urgency of climate change and the increasing of social, environmental and economic pressures, ask for immediate intervention. The new shift in paradigm is called Post-Carbon City, and it indicates a rupture in the carbon-dependent urban system, to restructure human-ecological and human-human relationships. What tools and assessment methods are the most efficient to provide a strong response to this critic and urgent situation? How can we promote sustainable change?

Policymaking for sustainability constitutes an important aspect of decision-making. To decide for the future implies dealing with many factors: uncertainty, a plurality of actors, goals and expectations. The difficult assessment of costs and benefits is due to the presence of externalities, risks, and interplay of human beings and nature.

To plan for a desirable future, we need to look backwards from that future to the present and find all those links connecting the future with the past. In this way, we can strategize and plan how to achieve the future we desire. This methodology is called backcasting, and it is very useful when problems at hand are complex.

This paper provides a description on how backcasting methods can contribute in assessing long-term sustainable solutions for post-carbon city planning, with a particular focus on lifestyles, behaviour, and the concept of temporal coherence within urban systems.

POST-CARBON CITY PLANNING

Backcasting methods in assessing long-term urban solutions

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1_Introduction

If we want to give a practical and immediate response to the radical changes in urban dynamics that have occurred during the last decays, a new systemic approach is required. What desirable future scenarios? How to involve different stakeholders in a planning process by dealing with complex issues? These and many other questions arise when we deal with post-carbon city planning.

To plan for a sustainable future and to reduce emissions and their environmental impact, technical issues are not enough: advocacy and policy, as well as community lifestyles and behaviour, play an important role, and they require more and more attention.

Over the last decades, many countries and cities have adopted greenhouse gases emissions (GHG) reduction targets in their policies. These objectives that often reach to 2050 have extended the time horizon of the political debate. Transformations towards a low-carbon future require a considerable effort in technological, economic, and social terms. The transition away from fossil fuels is the key to a sustainable, renewable, resilient future. It is a process that has to start now, although its effects manifest in the medium and long time term.

When talking about a distant future, many questions like “will life be more complicated” or “where do I get my income from” arise (Neuvonen et al. 2014). Uncertainty is an inevitable aspect of planning for the future. To deal with uncertainty requires accepting the risk to fail. Nevertheless, immediate action is required. What is the right direction to take? How can we make best choices? How can we identify and prioritize all factors influencing the possible alternatives for action? Policy decisions involve many aspects including environmental, economic, technological, ethical, and they can affect the future over different time horizons. To make the best decision we must examine all the possible alternatives in a conscious and systematic way (Saaty, 2013). To approach a complex problem, and to make complex decisions, the best way is to structure all the important key influences affecting all the alternatives we can think of.

When dealing with Post Carbon City Planning, approaches need to be strategic, conscious, and systematic. One suggestion was provided by Daniel Lerch from the Post Carbon Institute in Santa Rosa (USA).

In his Guidebook on Peak Oil and Global Warming for Local Governments, he suggested that to achieve the goals of breaking dependence on community from oil, reduce global warming, and be prepared to thrive future climate and energy uncertainty the most successful strategy is "to reduce consumption and produce locally" (2007: v). The Guidebook was addressed mainly to Local Governments, whose role in reducing emissions and energy consumption has been widely recognized to be central.

The necessity of reducing the environmental impact of human activities has been felt by several countries since the beginning of the twenty-first century, and even before.

In 1999, the Swedish Parliament adopted fifteen environmental objectives, with the aim of ensuring the major environmental problems of the country to be solved by 2020. Few years later a sixteen objective was introduced (Svenfelt et al., 2011). The adopted quality goals point the way to a sustainable society. They cover many fields of intervention: unpolluted air, zero eutrophication of lakes and forests, a healthy built environment regarding reduced emissions and quality of life are just a few examples.

The sixteen quality objectives are an indication of how complex and diversified the areas involved in sustainable planning for the future are.

To plan for the future requires studying the future. The initial thought behind the necessity of considering the future derives from the human need for general awareness of time and temporal consciousness of past, present and future.

Studying the future involves clear thinking about alternative futures. It requires an understanding of possible alternative futures world.

In Future Studies, applied methodologies such as Environmental Scanning, Visioning, Content Analysis, Delphi, Global Modeling, Time Series Analysis, Field Anomaly Relaxation, derive from multiple disciplines and are differently constructed when applied to future studies. The Future Studies purpose is not to determine or predict the future; rather it is to consider potential changes and help taking better decisions for the future, to address opportunities and turn weaknesses into potentialities.

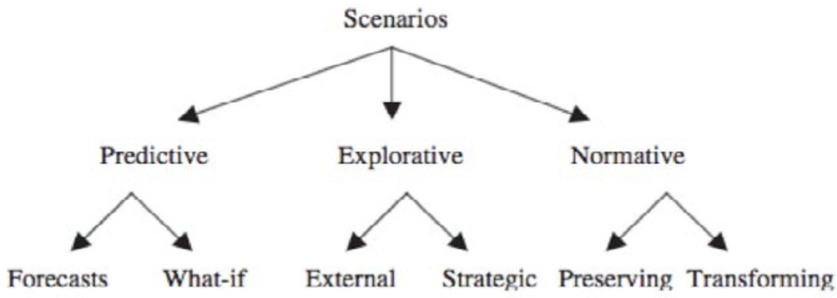
How can Future Studies help in post-Carbon City Planning? What approaches and suggestions have been proposed in the literature during the last decades? Does thinking about the future imply merely looking "forward" or should we need to change direction and try to look "backward"? This paper provides suggestions for answering these questions. It also provides suggestions for an integrated approach to sustainable urban planning based on the Temporal Analysis, which has its roots in Hermann Dooyeweerd's philosophy of Reality.

2_Backcasting: starting from the future to plan for the future

One of the approaches used to explore, create and test probably and desirable futures to improve long-term planning is backcasting.
The origin of backcasting dates back to 1970 when Lovins applied it as a planning methodology for electricity supply and demand (Quist, 2007). He called this methodology backwards-looking analysis, and he argued that «It would be beneficial to describe a desirable future or a range of desirable futures and to assess how these futures could be achieved, instead of focusing only on likely futures and projective forecasts». (ibid.:18)
Since that date, backcasting has been used in planning and policy activities by governmental and non-governmental organizations all around the world, thanks to its successful application to a great number of subjects.
Is backcasting an approach or can it be considered a method? In the paper Essence of backcasting, Dreborg asserted that «It is not a method in any strict sense, nor does it require any particular backcasting methods. Clearly, a backcasting study depends on scientific methods for its credibility – and this is the context of justification – but these methods should be chosen in accordance with praxis within the scientific disciplines involved. The problem at stake will, in turn, determine the relevance of different disciplines». (1996: 819)
More recently Quist asserted that «Reports on backcasting methods are hard to find…therefore conventional methods have to be combined in backcasting approaches. This calls for a more detailed exploration of various backcasting approaches». (2007: 24)
In 1988, J.B. Robinson discussed an important issue related to backcasting: the role of learning and unlearning on the existing dominant views of the future. He focussed on the importance to alter the hegemony of the current dominant perspectives. It is an important issue: breaking powers requires to propose valid alternatives. It requires being courageous enough to abandon the bias that influence our personal thinking or judging.
Refusing the bias implies self-critique. It means to accept the risk of denying what we have been till today. Certainty versus uncertainty: this is the first challenge we need to face if we want to avoid that «Our perception of what is possible or reasonable may be a mayor obstacle to real change». (Deborg, 1996:816)
According to the literature, backcasting is an approach using the most different methods, depending on the field of investigation. It can use Predictive, Explorative or Normative scenarios. Each of them tries to find an answer at various starting questions:

- The Predictive scenarios respond to "What will happen?"
- The Explorative scenarios respond to "What could happen?"
- The Normative scenarios respond to "How can a specific target be reached?"

Figure 1. Scenario typology. Source Borjeson et al., 2006: 725.



The normative approach to backcasting can be defined as the most significant one. Instead of predicting what will or could happen in the future, the aim is to indicate how to reach a specific and desired target in the future. It is an important aspect of normative backcasting as it suggests a different concern of the future: not as an end rather than a starting step. Hojer et al. assert that a normative scenario «Starts out from some kind of norms in the form of explicitly stated targets». (2011: 820)

They indicate two different approaches to normative backcasting: the one uses preserving normative scenarios, the other using transformative normative scenarios.

The difference between the two lies in how challenging is for an institution to reach the target.

Building scenarios is a pivotal phase in backcasting approach. It is of evidence that different initial predictions produce different final effects (Wangel, 2011). For this reason, scenarios have to «Reflect solutions to a specified societal problem… a backcasting study may question some suppositions inherent in prevailing perceptions, and open some new options». (Dreborg, 1996: 816 -817)

Post Carbon City Planning requires structural change, both in economic, infrastructural, technological, and social terms.

In the last years, to face the urgency of climate change, technological solutions to emissions reductions or the use of alternative energy production have been widely proposed. Although there is an increasing awareness of the critical situation that the globe is facing, to give a more concrete response, the involvement of a larger number of stakeholders is required.

The transition to post-carbon city also requires a change in behaviour and lifestyle as «It is somewhat likely that transitional changes in technology, economy, laws, and value structures lead into changes in lifestyles as well. Secondly, both the adoption of new technologies and advancements in policies are dependent on social structures and changes in behavioural patterns….For instance, a company offering a service for shared car usage today can serve as an agent for change for the society tomorrow». (Neuvonen et al. 2014: 67)

According to Robinson, the future is a function of choice and behaviour in the present. For this reason, he suggested backcasting as a new view in the field of generating and testing different images of the future. In fact, he criticized the traditional forecasting for several reasons «First, despite the unknowability of the future, many forecasting analyses represent attempts to predict the future. Second, although a necessary reliance on data from the past imparts a status quo basis in forecasting, the prospect of surprises or unlikely events is rarely treated in the analysis. Third, using forecasts to justify policy decisions allows there to occur a curious reversal of cause and effect whereby present decisions are "caused" by predictions of future events: in fact, future events are themselves largely the result of such present decisions. Fourth, this reversal of cause and effect is often allowing forecasts to be used to legitimize essentially normative policy decisions, to cover them with a spurious cloak of objectivity, and to reduce or eliminate the possibility of creative policy choice. Finally, as forecasts horizons lengthen and widen, there is often a tendency simply to extend the horizons of conventional models, and retain the goal of reliable prediction, rather than change both the nature of the models and the goals of the analysis to reflect the changed conditions. (1988: 325-326)

Robinson suggests a focus on some important aspects related to future studies:

- The future is unknowable and tough to predict;
- Uncertainty influences predictions, and it 's hard to consider appropriately;
- Forecasting tends to follow trends with less space for alternative solutions.

After more than twenty-five years, the above-listed aspects are of actuality in the ongoing discussion on future studies.

According to Robinson (2003), although backcasting finalizes at assessing feasibility and desirability, rather than a likelihood, it is inevitably conditioned by discussions on possible futures.

He asserts that «The claim that backcasting is a non-predictive approach to the future does not imply the lack of inclusion of conditional predictions in the analysis». (p. 853)

Planning for the future requires approaching the future itself by conjoining two opposite directions: backward and forward.

The normative backcasting approach to future planning has been widely used by many scholars during the last years.

This paper wants to focus on the temporal dimensions of urban contexts as well as on social behaviour and lifestyle as training engine in the necessary transition to Post-Carbon City.

2.1_Backcasting and the use of time and space: how behaviour can impact on the urban structure at the city scale

An application of the backcasting approach has been provided by Hojer et al. (2011) for Stockholm 2050. The aim of the study was to develop images of the future with a reduced energy use by 60% in the period between 2000 and 2050. The proposed perspective is the households one, and the use of energy is analysed from the individuals' activities allocation.

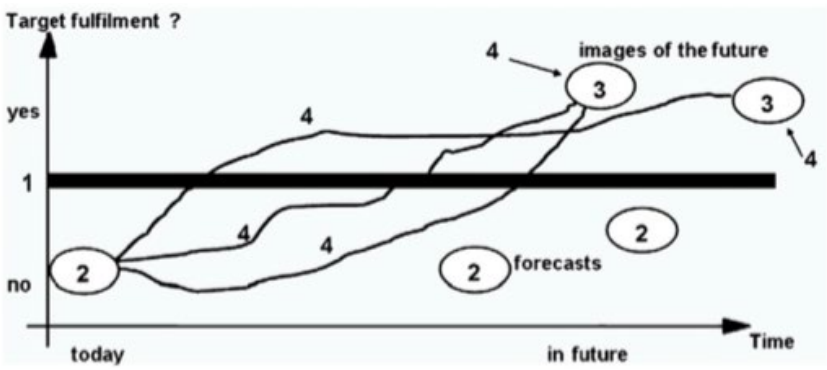
The authors suggest a study aimed at defining possible visions of the future city and city life that successfully address the climate change challenge concerning spatial and temporal dimensions. The research question was «How a combination of spatial city planning and changed use of time can be an effective tool for strategy development towards a transition to a low-energy city». (p. 819)

The proposed study bases on a four step target-orientated backcasting approach:

- The first step is the definition of a long-term target, which is called the *sustainable use of energy by the inhabitants of Stockholm*. It is the grounding step aimed at defining a highly prioritized societal goal. This step was operationalized through the Intergovernmental Panel of Climate Change (IPCC, 2014) target that includes a 20-30% reduction of GHG emissions by 2020, and a two-degree as the maximum increase of global temperature.
- The second step is the *analysis of the feasibility of the target*. This analysis has been conducted by considering the current trends shown by the available energy forecasts (a 60% GHG reduction has been demonstrated to be challenging for Sweden).
- The third step focuses on the *target fulfilment*. This phase includes historical data analysis, trend analysis, and the definition of a range of possible opportunities (possible scenarios) within different fields of investigation. Methods used in this phase are creative workshops, expert judgements and quantitative statements, all combined. During this stage, images of the possible future have been elaborated concerning the urban structure (regarding space), and Households Activity patterns (in terms of time use).
- The fourth step is the *analysis of the images of the future* intended as target fulfilment of the sustainable energy consumption. This phase helps in defining general trends counteracting the objective achievement, benefits and barriers, weaknesses and potentialities that influence the process towards target fulfilment.

The four steps have been graphically represented by the authors as follows

Fig. 2. Four steps of Backcasting.
Source: Hojer et al. (2011:821).



Line 1 represents the definition of the target (phase 1).

The circles n. 2 (phase 2) are the analysis of the target by focusing on the current trends while the circles n. 3 are the images of the future that satisfy the fulfilment of the target.

The fourth phase represents a line connecting the images of the future meeting the target and the current trends.

It is a backward analysis indicating what actions need to be taken today in order to satisfy the future goal.

The above graph is an adaptation of the one proposed by Dreborg in 1996

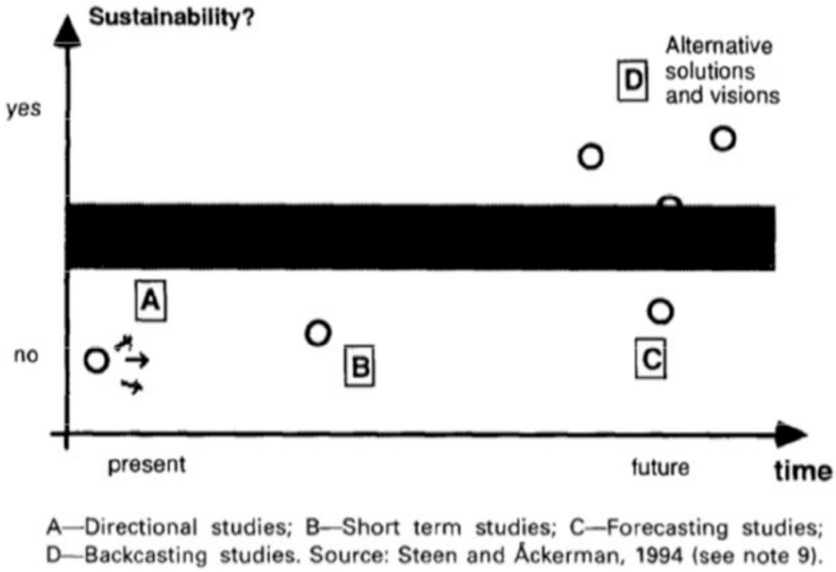


Figure 3. Source Dreborg (1996:815).

that was aimed at demonstrating how backcasting is necessary to widen the scope and provide a major change towards sustainability.

The analysis related to Stockholm 2050, based on the principle that the use of space and time can influence the transition to low-carbon living, suggests:

- The definition of three different ways of developing city structures: urban cores (the traditional city centre with an emphasis on megastructures), suburban centres (a strong city centre and an efficient transport system along radial lines out of the city centre), low-rise settlements (emphasizing the demand for living in the countryside, with a little home garden at its base);
- The definition of Tempo of life as pivotal for energy use: how and how much time people allocate in different activities. The focus is on the speed of lifestyle: fast indicates people are working much, earning money, leading fragmented lives. Energy use is dependent on technological fixes, and it is reduced through a change towards a service economy. On the opposite, slow indicates a situation where people work less than today, they earn about the same amount of money, and there is more deliberate consumption of products. There is also lower demand for travel.

The above two principles focus on the important relation existing between urban form and Tempo and, by consequence, between them and energy reduction. The way people use urban space and individual time allocation influences the use of energy. Therefore, focussing on these two dimensions can help in understanding how to behave to reach the target, as well as the future urban structure evolving patterns.

By combining the three outlined developing city structures with fast and slow use of Tempo (six scenarios), the study provides the following end results:

- The total energy use is the same in each of the six scenarios;
- Five major challenges to the sustainable city images have been defined:
  - The reduction in the total energy use;
  - The reduction of the heated space;

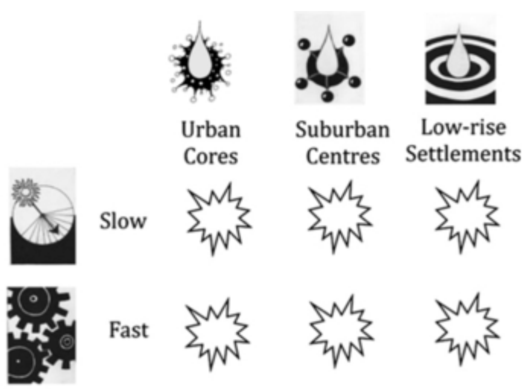


Figure 4. Images of the future. Source Hojer et al. (2011:828).

- A change in cooking and eating habits through promoting the consumption of seasonal food
- The reduction of air travel by implementing high-speed ferries
- A drastic reduction of car commuting and commute length.

According to what asserted by the authors «Low-rise settlement – Fast is somewhat difficult to imagine, as it consists of rich urbanites who chose to live at some distance from the city, but do not use cars a lot. It would probably require a substantial change in norms and values, very tough control measures or a very high cost of driving, but in that case, one of the other two urban forms would probably be more attractive. Thus Low-rise Settlement – Fast is an inconsistent image of the future». (ibid. : 832)

This study is an interesting contribution to the discussion on the application of Future Studies to Post-Carbon City planning. It provides indications on how behaviour has to change to reach the established target.

Differently from the common use of backcasting approaches, Stockholm 2050 gives an inside into societal aspects at a city scale, and it focuses on individual rather than on sectoral energy consumption.

The authors' conclusions lead to interesting considerations:

- To meet the target, changes of the same factors are necessary within all the different scenarios: let's call it the *constancy principle*;
- Changes of these factors can be achieved through various solutions and developments: the *variety principle*;
- Technology plays a significant role in all scenarios, and it can help reducing drastically energy use and consumption: the *training force*.

2.2_From sustainable behaviour to sustainable lifestyle. A backcasting approach at the European scale

The concept of sustainable lifestyle was firstly introduced by the United Nations Commission on Sustainable Development (CSD) in 2004. The term indicates the necessity to link three focal points dominating the agenda of sustainable development: cleaner production, local action and participation, sustainable consumption (Neuvonen et al. 2014).

If a behaviour is the result of a complex mix of principle, values, attitudes and surrounding infrastructures (DEFRA, 2013), sustainable lifestyles can be shaped through social as well as technological innovation (Mont et al., 2014). Social patterns are quite unexplored fields in backcasting approaches to Post-Carbon City transition. Although backcasting applications during the last years have been more participatory, a multilevel perspective to societal change requires more effort.

The concept of lifestyle as leading in the post-carbon transition has been adopted by the research project Spread Sustainable Lifestyles 2050 (SPREAD), which was funded as part of the European Commission Programme 7, and that was coordinated by the UNEP in 2010-2012.

The project was a European social platform involving different societal stakeholders, to develop a common vision of sustainable lifestyle for 2050. The grounding principle of the project was that to reduce emissions and impact on the environment, a change in lifestyle is required.

SPREAD was thought as a common process for all Europe. Therefore, involvement and participation were implemented through an informatics platform (www.sustainable-lifestyles.eu).

The project proposed four alternative scenarios to reach the target of not exceeding the Planetary Boundaries. Scenarios had been built by using a backcasting approach based on the following phases:

- A vast number of niche level sustainable lifestyles were collected and analysed by using a multi-level and a multi-stakeholder change process (Geels, 2002).
- By using Delphi survey and other techniques like generating, integrating and consistency ones (Borjeson et al. 2006), two critical variables or uncertainties were defined. These variables were combined to create four alternative future landscapes forming the basis in the backcasting workshop.
- Fifty-four participants from sixteen countries were gathered for the backcasting workshop. They represented stakeholder groups from the business, governmental, research, entrepreneurial sectors, as well as independent policy experts. The workshop involved the participants in a counted backwards exercise from 2050 to today. The result of the workshop was the definition of four alternative scenarios to sustainable lifestyles in Europe between 2012 and 2050.
- A second Delphi survive based on participants' field of expertise was applied to refine and qualify scenarios.
- To add the view of the citizens, the resulted scenarios were discussed during five public workshops across Europe.

Without going too much into the project, the SPREAD approach is an interesting despite complex one. In this project, backcasting has been applied on a European scale, and data as well as uncertainties and possible variables influencing the process are difficult to control.

If we compare SPREAD with Stockholm 2050, the main differences are the following:

- The scale of the project.
- The level of perspective adopted for the analysis.
- The level of accuracy of the obtained results.

For what the main analogies between the two projects is concerned:

- Both of them are target oriented. They evolve through specific steps that are consequentially linked.
- Both of them focus on behaviour and lifestyles, although on different levels.
- Both of them focus on the importance of defining possible critical variables affecting the process.

3_A practical application at the local scale. The Dooyeweerdian Temporal Analysis and the role and meaning of temporal coherence

In 1969 Herman Dooyeweerd's four volumes masterwork *A New Critique of Theoretical Thought* was firstly published. Herman Dooyeweerd (1894-1977) was a Dutch philosopher. He defined fifteen modalities to describe reality as a systemic not casual combination of different aspects.

In the introduction to his work Dooyeweerd asserted «If I consider reality as it is given in the naïve pre-theoretical experience, and then confront it with a theoretical analysis, through which reality appears to split up into various modal aspects, then the first thing that strikes me is the original indissoluble interrelation among these aspects which are for the first time explicitly distinguished in the theoretical attitude of mind». (1983:3)
The strength of the Dooyeweerdian philosophy resides in his vision of reality as a system having coherence thanks to Time.
Temporal coherence, as intended by Dooyeweerd, can be defined as the stream of meaning necessarily existing between modalities. This relation is expressed by the *analogical moments*, which define anticipation nad posticipation (postponing), connecting aspects just as rings in a chain (De Iuliis, 2010).
The analogical functions of *anticipation* and *retrocipation* define the interlacement of modalities. Following this principle, later modalities are structured on the early ones. In this way, the model of reality proposed by Dooyeweerd can be read in a systemic way, having a coherence in the interrelation existing between all the aspects.
In 1954 Dooyeweerd wrote «Every aspect of experience expresses within its modal structure the entire temporal order and connection of all the aspects [...] it can express the nucleus of meaning of the aspect only in connection with a series of analogical moments of meaning which refer back to the nuclei of meaning of all the earlier aspects and, on the other hand, point forward to the nuclei of meaning of all the later ones». (1954, 2)
Applied to the planning discipline and practice, Dooyeweerd's philosophy and the concept of temporal coherence can provide useful and interesting results. In particular, its application in backcasting approach provides indications on how to reduce uncertainties and improve objectivity in planning.
The application of Dooyeweerd's philosophy of Time to planning discipline and practice was the subject of a PhD thesis titled *A Dooyeweerdian approach to Time in Sustainable Development* (De Iuliis, 2010). This study developed a framework, called the Temporal Table, whose aim was the evaluation of the temporal coherence within urban contexts, and the definition of the existing relations among the different time horizons considered in economic, human, political, and environmental terms.
In 2008, the temporal analysis was applied to the village of Santo Stefano al Mare, on the Ligurian West Coast, as selected case study. In particular, four different green public areas were analysed in order to find possible future planning solutions for them.
A double direction analysis was elaborated: backwards (from the present to the past), and forewards (from the present to the future). The aim was to define possible future planning solutions (scenarios) by starting from the context, which is intended to be the result of past synergies.
The proposed Temporal Analysis has been developed into the following phases:

1. *Gathering data for Context building*. The backward direction of the analysis provides an accurate definition of the existing strengths and weaknesses of the areas as part of the entire urban system. In this phase a set of temporal issues are provided.

2. *Context building: The Temporal Table backwards*. Which aspects of the system have been mostly affected by change?
3. *From the Present to the Future*. The Temporal Table forward. Possible scenarios for future planning. Understanding immediate and after (delayed) change with relation to future expectations;
4. *End results*. TheTemporal Diagram;
5. *From the Future to the Present*. Backcasting for the definition of actions.

The above analysis provides an approach to urban change following opposite and conjoined directions (backward, forwards, and backward again).
The focus is on an accurate building of the present context by the definition of past temporal urban synergies between the aspects describing reality. The keystone is change, that is intended to be the moment the system is somehow modified by occurred events. The succession of past events and the impact of them on the aspects of reality define strengths and weaknesses of the system itself (within each aspect).
The backward temporal analysis is an important phase as it helps building the context. The more accurate the analysis, the more uncertainty is reduced in the following phase of scenario building.
Once having defined scenarios, the application of each of them to the context by the use of the Temporal Table suggests what possible immediate and delayed change could occur within each aspect of the urban context. Key question in this phase is "what will happen if I apply that scenario to that context, with those temporal issues?"
The temporal Diagram is a graphical representation of the obtained results: it indicates what aspects of the urban contexts are weaker, what are stronger, what impact in what time horizon will produce a specific action (scenario) on the system.
The application of backcasting to the obtained results helps in deciding for the best solution for the future. Once decided the target to fulfil in the future and the temporal horizon for it, key question in this phase is "what actions to reach the target without compromise the urban system, rather by turning weaknesses into potentialities?"
The Temporal Analysis has been applied to four green public spaces within the village of Santo Stefano al Mare. In the following section, results obtained by the analysis of the green area in front of the primary school are going to be exposed.

3.1_The case study: the garden in front of the primary school

The garden in front of the primary school was built in 1932 as a unitary project with the public building on the opposite side of the road. At that age, the west side of the village was a border area where a group of families lived in few residential houses.
Santo Stefano al Mare had become a municipality in the second half of the nineteenth century, and its domain was extended to the next village of Riva Ligure. The building of a new seat for the school and the Town Hall was an attempt to dislocate public services and to create a connection between the west area of the village and the old centre. This important event took place

after the building of the railway network and the Aurelia Street, both of them crossing the village.

First phase: gathering data for context building

This phase is the backwards analysis applied to the whole urban system, and the studied area is considered as part of it. The evolution of the urban structure in 1932 is described by the following graphical representation, called the temporal line:

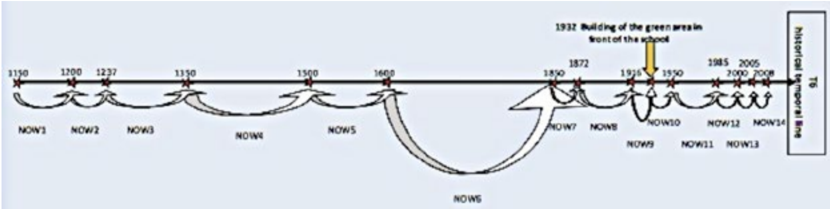


Figure 5. The Temporal backwards line. Source De Iuliis, 2010:241.

The yellow arrow indicates the moment along the temporal line the green area in front of the school was realised. As stated above, the analysed green area is located in the west side of the village. Many of the important events that have defined the evolution of the urban context did not influence directly this side of the village, which maintained its character of a boundary area.
The above represented temporal line indicates that between 1850 and 2008, the rhythm of succession of change due to significant actions on the municipal territory increased. This was due to the building of new infrastructures that changed the inner and outer synergies of the urban system.
Based on the above temporal line, a set of temporal issues for each aspect describing the urban context has been defined.

Table 1. Urban Temporal Issues. Source De Iuliis, 2010.

Aspects	S Temporal Issues
Numerical	---
Spatial	*Distances between spatial boundaries:* The territory of the village is defined by two rivers, Santa Caterina in the west side and Aregai in the east side. Along the seaside, the ancient promenade connected the west side to the parish church. A new road was built in 1916–18 in the northern side of the village. A new railway network crossed the centre of the village. *Location and footprint of the buildings with respect to the urban space:* The old centre was a well-defined and compact-building nucleus. In the west side of the village, few residential houses characterized the urban space. In 1932 the village was composed of two urban nuclei. *Spatial relation between natural and anthropical environment:* Between the two existing urban nuclei (the centre of the village and the district near Santa Caterina River), the field along the seaside was partly cultivated. The natural and the anthropical environment were interrelated. The first one was wider than the second one with respect to the municipal territory.
Kinematic	*Spatial character of a location while going through it:* Transport had become more comfortable and quick by consequence of the building of the new road and the new railway network. The railway network crossed the old centre of the village, creating a separation, a "wound."
Physical	*Laws and norms of physics that regulate cause-effect processes:* The building of Aurelia Street, as well as the building of the railway network, implied important works. It had a great impact on the environment and on the physical structure of the soil.
Biological	*Equilibrium of the organisms in the environment:* The building of the new road caused the alteration of a piece of environment. Ancient rural properties disappeared in order to make room for the road. The building of the railway network interested the urban area. Ancient houses were demolished, and some small gardens and orchards disappeared. *Natural balance:* the natural balance was not altered.
Sensitive	*Memory and pattern recognition, which defines subjective background and influences subjective perception of the surrounding environment:* The evolution of the urban structure, the existence of two separated building nucleus, the new road, and the railway network, together with the hills and the sea, define the surrounding environment.

Analytical	The analytical modality is defined by the S temporal issues of the sensitive one.
Historical	
Lingual	*Coexisting elements of utterance in order to form clear messages:* Symbols and signs are visible in the territory. The municipality informed about the building of a new road and the railway network. In Santo Stefano al Mare, there was also a railway station where people could inform about the train timetable.
Social	*Shared background knowledge:* The community shared its common background. The nucleus in the west side of the village evolved independently from the old centre. Although it was connected to the next village of Riva Ligure, the sense of identity as citizens of Santo Stefano al Mare was very deep.
Economic	*Conservation of resources in terms of relation of needed available resources:* The economy had changed. Agriculture was slowly turning into floriculture. The community lived mainly on local products. Quite each family had a garden and produced vegetables.
Aesthetic	*Equilibrate relation of citizen-surrounding urban context:* The community lived in relation with the countryside and the seaside. Agriculture and fishing were not just economic activities, but also an occasion for spending time in open air. The community lifestyle is grounded in a deep relation with the natural environment.
Juridical	*Laws, rules, and norms in charge influencing planning activity:* No planning law was in charge in that period. The first national planning law dates back to 1942. Before that period, building activity was not subject to licence.
Ethical	*Background, family, friendship, education:* The family played an important role in the community life. Religion influenced private and social life. At the beginning of the twentieth century, the religious foundation Queen Margaret established the local nursery school. It exists and operates nowadays.
Creedal	*What is right and what is wrong in terms of choice for action:* The citizen shared the administrators' decisions. The important works (the new road and the railway network across the village) were seen as modernization of the village. The community's expectations were about a more comfortable and modern lifestyle.

The temporal issues provide an immediate punctual description of the urban temporal evolution with reference to each aspect. Data and information of the temporal line are translated into the different temporal issues that will be used in the Temporal Table.

Second phase: building the context. The Temporal Table backwards and the definition of immediate and delayed impacts for change

The historical temporal analysis – backward direction – provides a definition of the proposed green area in terms of its spatial location with relation to the temporal evolution of the whole urban system. The aim is to delineate the peculiar multiaspectual temporal character of the play garden in order to understand how problems arose and to determine the possible directions of future planning.

The Temporal Table is conceived as a framework built on the following elements:

- Issues of the built environment as defined by Prof. Patrizia Lombardi (1999). Each group of issues refers to a modality define by Dooyeweerd;
- Temporal issues providing information collected in the previous phase. Each group of temporal issues refer to the issues of the built environment. The temporal issues have a double function: the before and after function, and the simultaneity function. The difference between the two depends on the time required by change to manifest within each modality.
- A focus on the aspects that are deeply involved at the moment the change occurred. For example the building of a public garden in 1932 merely interested the biotic, analytical and juridical aspects. Impacts of this action (building of a green area) on the whole urban context are provided by the Temporal Table in terms of immediate and delayed change.

Table 2. The Temporal Table and the definition of cause and effects. Source: De Iuliis, 2010.

HISTORICAL ANALYSIS *backward direction* NOW10: 1932/1950 Change: the building of a green public area in front of the Town Hall and primary school aspect of the built environment – biotic, analytical, and juridical			
Modalities	A Issues of the built environment (Source: Prof. Lombardi's thesis)	B Temporal issues BA (before and after function)	C Temporal issues S (simultaneity function)
Numerical	Population (human), amount of various resources available, number of species and their population levels, statistical census offices	- Increasing or decreasing of population: ***subject to change***; **more people in the district. The public building, seat of the school and the Town Hall, dislocated public service from the old centre to Santa Caterina area. More affluent citizens and scholars during the day.** - increasing or decreasing of resources available: ***subject to change*. The public building was realized in place of private gardens. This reduced the rural activity that people still played in the area.** T0: reduction. No numerical data are available.	– – –
Spatial	Layout, shape, building footprint, location, proximity, terrain shape-flat, mountainous, etc., neighbourhood area, urban area, district area, etc.	– – –	- distances between spatial boundaries: **geometrical distances: *not subject to change*.** **Social distances: *subject to change*. The dislocation of functions "reduced" the distances between the old centre of the village and the district.** - location and footprint of buildings with respect to the urban space: ***subject to change*. The new public building and the green area change the structure of the urban district. The urban structure of the village is still characterized by two nuclei.** - spatial relation between natural and anthropical environment: ***not subject to change*. The natural environment is wider than the urban structure.** ***Immediate change:*** **- the definition of the urban structure of Santa Caterina area** **- a nonmeaningful reduction of private gardens** ***After-change:* No meaningful spatial after change has been registered till now. The building of the new seat for the school and the Town Hall and the building of the green area in front of it have not caused meaningful change in spatial terms through time.**

Kinematics	Infrastructures, roads, motorway, railways, cycling roads, pedestrian streets, car parking, transport and viability, wildlife movement, mobility, accessibility.	- change of location, succession of places during movement: ***subject to change*. The public building and the green area change the environment around the main promenade, the road to the next village Riva Ligure.** T1: hours spent for going from the old centre to Santa Caterina District. Increasing value.	- spatial character of a location while going through it: ***subject to change*. The new public building and the green area change the spatial configuration of the district.** ***Immediate change:* a new urban configuration for the district (a building and a green public area in place of private gardens).** ***After-change:* no meaningful kinematic after change has been registered till now.**
Physical	Energy for human activity, energy for biotic activity, physical environment, structure of ground on which to build, building materials, components, buildings, districts, settlements	- increasing or decreasing of energy by consequence of a certain cause (waste disposal): ***subject to change*. The building of the school and Town Hall and the building of the new green area cause immediate influence on the structure of the ground.** T2: immediate impact: now (change from a *before* to an *after* situation)	- laws and norms of physics that regulate cause-effect processes: ***subject to change*. The new public building is an intervention causing a not meaningful impact on the soil. The area is flat and the building does not imply important excavations. Despite the area is in proximity of the sea, no water table has been found.** ***Immediate change:* (some physical relations are immediately altered.)** ***After-effects:* no after effects of physical alteration of the soil has been caused till today.**
Biotic	Food shelter, housing, air and air quality, water and water quality, hygiene, **green areas**, pollution, soil quality, biodiversity, habitat diversity and quality, resilience of ecosystems (ability to recover from imbalances), health and health services, hospitals, gyms BUILDING OF THE GREEN AREA	- time needed for a certain specie (animal or vegetal one) to develop or to regenerate: ***not subject to change*. The intervention has no great impact on the natural environment.** - succession of stages of growth: ***not subject to change*** T3: not relevant	- equilibrium of organisms in the environment: ***not subject to change*** - natural balance: ***not subject to change*** ***Immediate effects:* the area was not subject to immediate change in biological terms.** ***After-effects:* the area was not subject to after-effects in biological terms.**
Sensitive	Feelings engendered by living there, feeling of well-being, comfort, fitness noise, security, safety, privacy, provision of peaceful surroundings, e.g., motorway noise that prevents bird song operating, counselling services, asylums, houses for domestic animals	- perception of surrounding environment (facts and events) and subjective immediate response (sense of well-being, orientation and identity): ***subject to change*. The spatial definition of the area (by the building of the new Town Hall and school) changes the citizens' perception of the urban context.** T4: quantitative temporal dimension	- memory and pattern recognition which define subjective background and influence subjective perception surrounding environment: ***subject to change*. The built Town Hall and school and green area become signs and symbols of the community life.** ***Immediate effects:* new signs and symbols within the surrounding environment overlap the existing ones (a new building, less private gardens, new public green area in front of the seaside).** ***After-effects:* new patterns recognition becomes part of the subjective orientation system.**
Analytical	Clarity with which issues are aired in the community, letting people clearly know facts and issues, quality of analysis for planning and evaluation, diversity, functional mix, knowledge, tendency to	- ordinate succession of events: ***subject to change*** - subjective and collective priorities: ***subject to change*** - attitude to choice: ***subject to change***	- memory and pattern recognition: ***subject to change*. The logical aspect has the same simultaneous character of the sensitive aspect. They both are rooted in past formative evolution.**

Analytical	understand rather than react to issues, **schools**, universities, education services, research BUILDING OF THE SCHOOL	- logical analysis: ***subject to change*** **The new public building and the green area have modified the citizens' way of inhabiting the urban space. New priorities influence attitude to choice.** T5: qualitative temporal dimension	***Immediate effects:*** **the new road changes citizens' "use" of the urban area.** ***After-effects:*** **new priorities in order to satisfy emerging needs, will influence personal choices.**
PAST		**PRESENT: the new garden**	**FUTURE**
Lingual, communicative	Ease of communication in the community, quality of communication (truthfulness, etc.), lingual networking, Symbols transferring, information provision, monuments, signs, advertising, the media	- time spent to communicate with respect to means of communication: ***subject to change, but not meaningfully.*** **People have occasion to meet and verbally communicate. The public building is an attempt to dislocate services, not to introduce new ones. In the new green area, people can stay and have a rest after school or after work.** - temporal identity and evolution of symbols and signs for one's sense of direction: ***subject to change***. **New advertisings are placed to indicate the new public services.** T7: little increasing value	- coexisting elements of the utterance in order to form clear messages: ***subject to change***. ***Immediate change:*** **new symbols and signs are available for language. More elements of the utterance coexist.** ***After-change:*** **new patterns of language develop.**
Social	Social relationship and interaction, recreational places, social climate, cohesion, plurality, competitiveness, collaboration, authority structures, social Register, clubs and societies	- time spent to socialize - time spent to share; ***subject to change***. **The new public building and the green area are occasions for meeting and socialize. The change is meaningful within the area (people meet there instead of in the old centre of the village), but it is not relevant in global terms (it is just a dislocation of functions).** T8: little increasing with reference to the global situation	- shared background knowledge The temporal dimension resides in the formative evolution of the community. The community has a rural and seafaring identity. People were used to work hard during the day and to meet in the evenings. ***Immediate change:*** **more connection between the old centre and the west side of the village; more occasion to share common background for the citizens.** ***After-change:*** **new possible directions for sharing common background.**
Economic (frugality, use and care of resources)	Use of land, use of replacement of renewable resources, use of nonrenewable resources, recycling schemes, attitude to finance, efficiency, financial institutions, offices, banks, stock markets, industrial plants	- time spent to recycle - time spent for recovery - time forecast for economic return of a specific activity - long or short term for jobs ***Not subject to change*** T9: not relevant	- conservation of resources in terms of relation of needed available resources: ***not subject to change.*** ***Immediate change:*** **not relevant.** ***After-change:*** **not relevant.**

Aesthetic (harmony)	Beauty, visual amenity and landscape, architecture and design, architectonic style, decoration, social harmony, ecological harmony and balance, art galleries, theatres	- time spent in theatres and art galleries. ***Not subject to change*** - time spent for natural environment (private and public green areas, gardens, open spaces, trekking, outdoor activities): ***subject to little change*. The green area offers an occasion for people to meet. The community has a rural and seafaring identity. The inhabitants owned fields in the countryside or private gardens near home. They spent many hours in the open air, and a new green public open space was not their primary need.** T10: amount of hours (quantity). Not relevant	- several things together contribute to the harmony. An equilibrate relation of citizen-surrounding urban context is grounded in a satisfying response to subjective and collective needs and expectations through time. ***Immediate change:* new occasions for spending free time.** ***After-change:* the building of the green area did not influence on the citizens' lifestyle.**
Juridical (what is due)	Laws and law-making, especially with regard to property, ownership, regulation and other policy instruments, contracts especially for building, rights, responsibilities, inequities, property market interests, democracy, participation, tribunals, **administrative offices**, legal institutions, political structures BUILDING OF THE TOWN HALL	- expiry date for planning instruments: ***not subject to change*** - prescribed time within which to start and to end buildings: ***not subject to change*** - expiry dates in building and planning office procedures: ***not subject to change*** - time horizons for programs and plans: ***not subject to change*** T11: length of time (quantity) not relevant	- laws, rules, and norms that are in charge and that influence planning activity simultaneously: ***not subject to change*. The first planning law dates back to 1942.** ***Immediate change:* none** ***After-change:* none**
Ethical	General demeanour of people toward each other, goodwill, neighbourliness, solidarity, sharing, equity, health of the family, voluntary centre	- time spent for one's neighbourhood: ***not subject to change*** - statistical variation of number of voluntary centres: ***not subject to change*** T12: amount of hours (quantity) not relevant	- background, family, friendship, education; these elements all together define the ethical subjective and collective sphere: ***not subject to change*** ***Immediate change:* none** ***After-change:* none**
Creedal, pistic	Loyalty to the community, general level of morale, shared vision of what we are (e.g., I shop, therefore I am; I am responsible to God), aspirations (e.g., to car ownership), shared vision of the way to go (e.g., Science-technology-economics will solve our problems), religious institutions, churches, synagogues	- time spent for religious activities: ***not subject to change*** - time horizon for subjective expectations - time horizon for collective expectations ***Subject to change*. The new public services in the area, as well as the green area, make the inhabitants to expect an increasing involvement in the village activity. They expect the renovation of the road system crossing the area, which was in that period not comfortable.** T13: temporal horizons for expectations; not registered	- what is right and what is wrong in terms of choice for action. The concepts of right and wrong are rooted in subjective and collective identity (social, religious, economic, political, etc., which coexist in a citizen and in his community): ***subject to change.*** ***Immediate change:* attitude toward the new public building and the green area. The citizens agree with it.** ***After-change:* expectations for a new way of living.**

The following table summarises results obtained with the application of the Temporal Table

Table 3. Impacts of the action taken "building of the green area" on the fifteen dooyeweerdian aspects.

	Immediate change	After-change	
Creedal	•	•	New expectations
Ethical	-----	-----	
Juridical	-----	-----	
Aesthetic	•	-----	No after-change within the aesthetic modality; loss of harmony for the scarce use of the green area
Economic	-----	-----	
Social	•	•	New patterns of language within the shared common background
Communicative	•	•	
Historical			
Logical	•	•	New pattern recognition; emerging needs and priorities
Sensitive	•	•	
Biotic	-----	-----	The five grounding aspects have not been meaningfully influenced by after-change.
Physical	•	-----	
Kinematics	•	------	
Spatial	•	-----	
Numerical	----	-----	No simultaneous character

Table 3 indicates that nine aspects of the urban contexts have been affected by immediate change deriving from the building of the green area, while only five have been interested in the long term.
Be the temporal context built, the next step is building future possible actions on the area.

From the present to the future. The Temporal Table applied at the forward direction

Once the temporal context has been built, the Temporal Table is used again to test possible future actions. The decision taken by the political administrators was to renew the green area. With this aim, in 2008 they financed a laboratory of participation project in the local school. During a week, seventy students were educated to *listen*, *smell*, *hear*, *watch*, and *touch* the garden in front of their school. Much useful information emerged from the laboratory. The students described the garden as not safe, not suitable for them to play in because of the rocky ground, the concrete benches, and the palm trees. They expected to have a garden on a children scale.
The need for a play garden, manifested by the students during the laboratory, has demonstrated that the discontent around the green area is grounded in its loss of a proper social-temporal identity. The historical analysis indicates that a link to the social sphere should be built.

Table 4. The Temporal Table forward direction. Source: De Iuliis, 2010.

PROPOSED INTERVENTION IN THE AREA *forward direction* NOW10: 1932/1950 Change: the building of a green public area in front of the Town Hall and primary school aspect of the built environment – biotic, analytical, and juridical			
Modalities	A Issues of the built environment (Source: Prof. Lombardi's thesis)	B Temporal issues BA (before and after function)	C Temporal issues S (simultaneity function)
Numerical	Population (human), amount of various resources available, number of species and their population levels, statistical census offices	- Increasing or decreasing of population: ***subject to change***; **more users in the area.** - increasing or decreasing of resources available: ***not subject to change.*** T0: expected increasing number of users.	– – –
Spatial	Layout, shape, building footprint, location, proximity, terrain shape-flat, mountainous, etc., neighbourhood area, urban area, district area, etc.	– – –	- distances between spatial boundaries: **geometrical distances: *not subject to change.*** **Social distances: *subject to change*; more students in the garden and more occasions to socialize for them and their parents.** - location and footprint of buildings with respect to the urban space: ***not subject to change.*** - spatial relation between natural and anthropical environment: ***subject to change*. The new garden is a projected green space.** ***Immediate change:*** **- more people in the area create a new social space. Social distances become shorter.** ***Possible after-change:*** **1. The new garden becomes a frequented place for a long time.** **2. The new garden is frequented for a limited time period.**
Kinematics	Infrastructures, roads, motorway, railways, cycling roads, pedestrian streets, car parking, transport and viability, wildlife movement, mobility, accessibility.	- change of location, succession of places during movement: ***subject to change*. The new garden changes the environment.** T1: hours spent for going from the old centre to Santa Caterina District. Increasing value.	- spatial character of a location while going through it: ***subject to change*. The new green area changes the spatial configuration of the district.** ***Immediate change:*** **a new urban configuration for the district (the project inserts new natural and building elements).** ***Possible after-change:*** **1. More users in the garden require more parking areas.** **2. No new parking areas are needed.**

Physical	Energy for human activity, energy for biotic activity, physical environment, structure of ground on which to build, building materials, components, buildings, districts, settlements USE OF SOFT MATERIALS	- increasing or decreasing of energy by consequence of a certain cause (waste disposal): ***subject to change*. The removed materials (waste) must be disposed of.** Most of the existing materials consist of stone and wood. The use of different materials introduces new elements. In order to create less impact on the ground and on the biotic aspect, recyclable natural material should be used. T2: immediate impact: now (change from a *before* to an *after* situation)	- laws and norms of physics that regulate cause-effect processes: ***subject to change*. The use of recyclable materials can mitigate the impact on the soil.** ***Immediate change:* some physical relations are immediately altered.** ***Possible after-effects:*** **1. Less after effects on the soil by the use of natural materials.** **2. The use of non recyclable materials alters the soil.**
Biotic	Food shelter, housing, air and air quality, water and water quality, hygiene, **green areas**, pollution, soil quality, biodiversity, habitat diversity and quality, resilience of ecosystems (ability to recover from imbalances), health and health services, hospitals, gyms RENEWING OF THE GREEN AREA	- time needed for a certain specie (animal or vegetal one) to develop or to regenerate: ***subject to change*. The project suggests the planting of new species. The existing ones (palm trees and fences) are removed.** - succession of stages of growth: ***subject to change*. New green species are planted in a newly realized "natural environment.** T3: subject to change from a before to an after situation	- equilibrium of organisms in the environment: ***subject to change*; new plants, new organisms.** - natural balance: ***not subject to change.*** ***Immediate effects:* the area is different in natural terms. New green species are planted, and they create a new "natural environment.** ***Possible after-effects:*** **1. The new green species grow up in their new environment.** **2. The new green species die because of the altered soil.**
Sensitive	Feelings engendered by living there, feeling of well-being, comfort, fitness noise, security, safety, privacy, provision of peaceful surroundings, e.g., motorway noise that prevents bird song operating, counselling services, asylums, houses for domestic animals	- perception of surrounding environment (facts and events) and subjective immediate response (sense of well-being, orientation and identity): ***subject to change*. The new garden is experienced through the senses (new coloured and aromatic plants, soft used building materials).** T4: quantitative temporal dimension. It represents the *duration* of the sensitive experience.	- memory and pattern recognition which define subjective background and influence subjective perception surrounding environment: ***subject to change*. New elements introduced in the garden by the project.** ***Immediate effects:* new signs and symbols within the surrounding environment overlap the existing ones.** ***Possible after-effects:*** **1. New pattern recognition becomes part of the subjective orientation system.**
Analytical	Clarity with which issues are aired in the community, letting people clearly know facts and issues, quality of analysis for planning and evaluation, diversity, functional mix, knowledge, tendency to understand rather than react to issues, **schools**, universities, education services, research	- ordinate succession of events: ***subject to change*** - subjective and collective priorities: ***subject to change*** - attitude to choice: ***subject to change*** - logical analysis: ***subject to change*** **The new green area has modified the citizens' way of inhabiting the public space. New priorities influence attitude to choice.** T5: qualitative temporal dimension	- memory and pattern recognition: ***subject to change*. The logical aspect has the same simultaneous character of the sensitive aspect. They both are rooted in past formative evolution.** ***Immediate effects:* the new garden changes citizens' "use" of it.** ***Possible after-effects:*** **1. New priorities in order to satisfy emerging needs will influence personal choices.**

PAST		PRESENT: the new garden	FUTURE
Lingual, communicative	Ease of communication in the community, quality of communication (truthfulness, etc.), lingual networking, Symbols transferring, information provision, monuments, signs, advertising, the media	- time spent to communicate with respect to means of communication: ***subject to change***. **People meet in the garden and socialize; oral communication.** - temporal identity and evolution of symbols and signs for one's sense of direction: ***subject to change***. **In order to make the garden safer and accessible to disabled people, new advertisings are placed.** T7: increasing value; more time spent to communicate	- coexisting elements of the utterance in order to form clear messages: ***subject to change***. ***Immediate change:*** **new symbols and signs are available for language. More elements of the utterance coexist.** ***Possible after-change:*** **1. New patterns of language develop.**
Social	Social relationship and interaction, recreational places, social climate, cohesion, plurality, competitiveness, collaboration, authority structures, social Register, clubs and societies	- time spent to socialize - time spent to share; ***subject to change***. **More students and more parents meet in the new garden.** T8: increasing; more time spent to socialize	- shared background knowledge The temporal dimension resides in the formative evolution of the community. The community has a rural and seafaring identity. People were used to work hard during the day and to meet in the evenings. ***Immediate change:*** **more occasions for the citizens to share their common background.** ***Possible after-change:*** **1. New possible directions for sharing common background.**
Economic (frugality, use and care of resources)	Use of land, use of replacement of renewable resources, use of nonrenewable resources, recycling schemes, attitude to finance, efficiency, financial institutions, offices, banks, stock markets, industrial plants	- time spent to recycle ***subject to change*** if recyclable materials are used. - time spent for recovery: ***not subject to change*** - time forecast for economic return of a specific activity: ***not subject to change*** - long or short term for jobs: ***Not subject to change*** T9: little amount, not relevant	- conservation of resources in terms of relation of needed available resources: ***not subject to change.*** ***Immediate change:*** **not relevant.** ***After-change:*** **not relevant.**
Aesthetic (harmony)	Beauty, visual amenity and landscape, architecture and design, architectonic style, decoration, social harmony, ecological harmony and balance, art galleries, theatres	- time spent in theatres and art galleries. ***Not subject to change*** - time spent for natural environment (private and public green areas, gardens, open spaces, trekking, outdoor activities): ***subject to little change***. **The green area offers an occasion for people to meet.** T10: amount of hours spent in the garden.	- several things together contribute to the harmony. An equilibrate relation of citizen-surrounding urban context is grounded in a satisfying response to subjective and collective needs and expectations through time. ***Immediate change:*** **new occasions for spending free time.** ***Possible after-change:*** **1. The renewed green area influences the citizens' lifestyle.** **2. The renewed green area does not influence the citizen's lifestyle.**

Juridical (what is due)	Laws and law-making, especially with regard to property, ownership, regulation and other policy instruments, contracts especially for building, rights, responsibilities, inequities, property market interests, democracy, participation, tribunals, **administrative offices**, legal institutions, political structures BUILDING OF THE TOWN HALL	- expiry date for planning instruments: ***not subject to change*** - prescribed time within which to start and to end buildings: ***not subject to change*** - expiry dates in building and planning office procedures: ***not subject to change*** - time horizons for programs and plans: ***not subject to change*** T11: length of time (quantity) not relevant	- laws, rules, and norms that are in charge and that influence planning activity simultaneously: ***not subject to change.*** ***Immediate change:*** **none** ***After-change:*** **none**
Ethical	General demeanour of people toward each other, goodwill, neighbourliness, solidarity, sharing, equity, health of the family, voluntary centres	- time spent for one's neighbourhood: ***subject to change.*** **The new garden is accessible also to disabled people.** - statistical variation of number of voluntary centres: ***not subject to change.*** **There are more accessible places in the village.** T12: amount of hours spent in caring for the community safety and sense of well-being.	- background, family, friendship, education; these elements all together define the ethical subjective and collective sphere: ***subject to change*** ***Immediate change:*** **more accessible area, more care for disabled people.** ***Possible after-change:*** **1. New safer and more accessible areas are built.** **2. No other similar interventions are proposed.**
Creedal, pistic	Loyalty to the community, general level of morale, shared vision of what we are (e.g., I shop, therefore I am; I am responsible to God), aspirations (e.g., to car ownership), shared vision of the way to go (e.g., Science-technology-economics will solve our problems), religious institutions, churches, synagogues	- time spent for religious activities: ***not subject to change*** - time horizon for subjective expectations - time horizon for collective expectations ***Subject to change.*** **The renewed green area makes the inhabitants expect an increasing attention for safety and well-being.** T13: temporal horizons for expectations; short term	- what is right and what is wrong in terms of choice for action. The concepts of right and wrong are rooted in subjective and collective identity (social, religious, economic, political, etc., which coexist in a citizen and in his community): ***subject to change.*** ***Immediate change:*** **attitude toward the new green area. The citizens agree with it.** ***Possible after-change:*** **1. Expectations for more similar areas in the short term.**

Immediate and possible after-changes can be summed up in the following table:

Table 5. Immediate and possible after changes by consequence of the action taken.

	Immediate change	After-change	Expectation for the future
Creedal/Piistic	•	•	Expectations for more similar gardens
Ethical	•	••	1. More similar areas (care for children and disabled people) 2. No more similar areas (the community gives no importance to more accessible areas by disabled people)
Juridical	-----	-----	
Aesthetic	•	••	1. The new area influences the citizen's lifestyle. 2. The new area does not play an important role in the citizen's lifestyle.
Economic	-----	-----	
Social	•	•	New patterns of language within the shared common background
Communicative	•	•	
Historical			

	Immediate change	After-change	Expectation for the future
Logical	•	•	New pattern recognition; emerging needs and priorities
Sensitive	•	•	
Biotic	•	••	1. The new green species grow up and proliferate 2. The new plants die because of the alteration of the soil
Physical	•	••	1. Use of natural recyclable material; reduced effects on the environment 2. Effects on the environment by the use of non recyclable materials
Kinematics	•	••	1. More parking areas required 2. Existing parking areas are sufficient.
Spatial	•	••	1. The new area is a frequented site for a long time. 2. The new area is frequented just for short periods.
Numerical	----	-----	No simultaneous character There is an immediate increasing of users

The following table describes the succession of immediate and after-changes as consequence of the use of recyclable and natural materials in the building of the projected garden. Number (1) indicates the action-use of recyclable materials, which defines the following immediate and after-changes:

Table 6. Analysis of possible effects. Source: De Iuliis, 2010.

Temporal Table forward direction Analysis of possible effects on the urban context, by consequence of the renewing of the play garden in front of the primary school Driving modalities: physical and biotic DIRECTION 1 - USE OF RECYCLABLE MATERIALS			
BE Issues	**BA Temporal Issues**	**S Temporal Issues**	
		Immediate change	**After-change**
Numerical	•		
Spatial	•		
Kinematic	•		
Physical	•	(1)	*
Biotic	•	2	*
Sensitive	•	3	10
Analytical	•	4	11
Formative			
Lingual	•	5	12
Social	•	6	13
Economic			
Aesthetic	•	7	14
Juridical			
Moral	•	8	15
Creedal	•	9	16

Table 7 shows that the use of recyclable materials mitigates the impact on the soil and, by consequence, on the biotic environment. This does not influence in a decisive way the double twofold possible after-change affecting the spatial, the kinematics, the aesthetic, and the ethical modality. Despite the care for the natural environment, it is not possible to define definitively the future implications derived by the renewed area on the urban context.

Table 7. Possible immediate and after-changes consequences derived from the use of recycled materials. Source: De iuliis, 2010.

	Immediate change	After-change	Expectation for the future
Creedal	•	•	Expectations for more similar gardens
Ethical	•	••	3. More similar areas (care for children and disabled people) 4. No more similar areas
Juridical	-----	-----	
Aesthetic	•	••	3. The new area influences the citizen's lifestyle. 4. The new area does not play an important role in the citizen's lifestyle.
Economic	-----	-----	
Social	•	•	New patterns of language within the shared common background
Communicative	•	•	
Historical			
	Immediate change	After-change	Expectation for the future
Logical	•	•	New pattern recognition; emerging needs and priorities
Sensitive	•	•	
Biotic	•	•	The new green species grow up and proliferate
Physical	•	•	Use of natural recyclable material; reduced effects on the environment
Kinematics	•	••	1. More parking areas required 2. Existing parking areas are sufficient.
Spatial	•	••	1. The new area is a frequented site for a long time. 2. The new area is frequented just for short periods.
Numerical	----	-----	No simultaneous character There is an immediate increasing of users

End results: the Temporal Diagram

The Temporal Diagram is the graphical representation of the possible future evolution of the green area within the urban context. It has been built on results obtained in the previous phases.

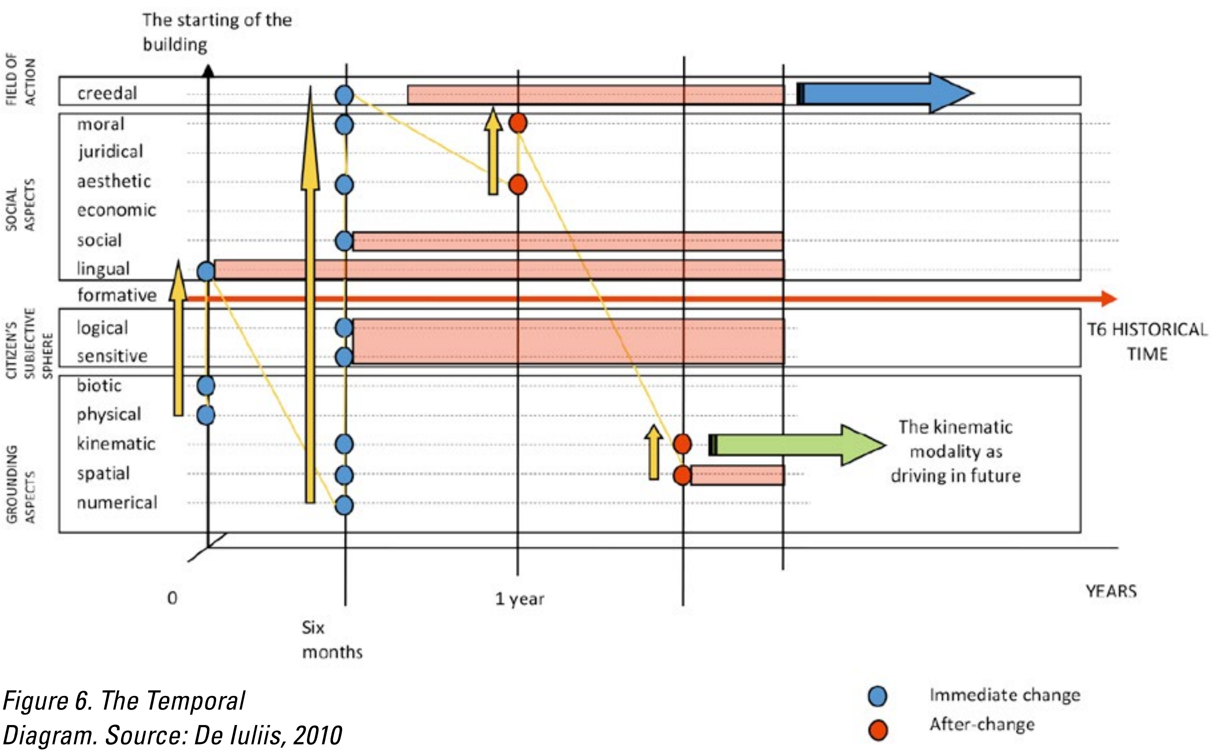


Figure 6. The Temporal Diagram. Source: De Iuliis, 2010

The above diagram represents the scenario of a future harmonic use of the garden by the community. It is supposed that the renewed garden becomes part of the citizen's everyday life, being able to affect their lifestyle. The blue circles represent the immediate change occurring within the modal order by consequence of the action taken (renewing the area by using recyclable materials). Very immediate effects take place in the physical and biotic modalities, which are the driving ones. A period of about six months is required for the other immediate effects to take place in the following modalities. Six months is the time horizon estimated for the works to be completed. During this period, the area is not accessible.
Figure 6 indicates that, after this period, an increasing number of users of the green area is registered. This data is available in the numerical aspect. The yellow arrow in figure 6 indicates the direction of *before and after*, which defines the temporal coherence between the aspects.
As supposed in figure 6, an increasing number of users causes the need for more parking areas. The green arrow indicates that this event – the need for more parking areas – causes future change. In fact, the action of building new parking areas causes immediate effects within the five grounding aspects. The kinematics modality becomes the driving modality for future change in the area by the building of new parking areas.

The temporal analysis of the possible future implications on the urban contexts, which derive from the renewing of the green area, suggests considerations on

- an estimated time horizon for the effects to take place. In figure 7 new meaningful changes are expected in about two years (very short time period);
- the definition of the driving modalities for future action.

With reference to the renewal of the play garden in front of the primary school, the proposed temporal analysis has suggested the following considerations:

1. The garden dates back to 1932. Until today, no relevant events occurred, which have directly influenced the structure of the area. With respect to the temporal evolution of the village, the play garden is quite a green corner in front of the primary school that is a very important public service. Near the school, a new residential area has developed, as well as a small harbour and a sport center. The district is very frequented, although the garden is not.
2. In 2008 the municipality financed a laboratory in the school that was aimed at planning new strategies for restoring the play garden. During a week, the students were involved in the *sensitive experience* of the garden. Through the senses, they came into contact with the soil, the existing green essences, the smells, and the materials in the garden. Following the sensitive experience, the students, together with the teachers and two architects, were asked for new planning ideas for "their" garden. In this phase of the laboratory, the *perceived* was logically analyzed by using sketches, checklists, examples, colours. The end result was a big map defining the project of the new garden.
3. The renewal of the garden following the developed ideas can have a positive impact on the urban context in environmental and social terms. The

building of a stronger social identity of the area and the increasing number of users makes the question of the parking area coming to surface. An obtained modal equilibrium within the analyzed subsystem – the play garden – requires action on the surrounding context. The expected time horizon is very short, and it implies action in the grounding group of modalities. This means that, in order to satisfy immediate needs, decision taken should be aimed at preserving the capacity of the urban system to maintain its *coherence*, for example by choosing strategic sites or proposing planning alternatives.

From the future to the present: backcasting to set actions

The above developed temporal analysis has suggested the direction to take to renew the garden. The set of possible immediate and after impacts derived from actions to be taken to fulfil the target (the renewal of the garden by the use of recyclable materials) provide useful information about the weaknesses and strengths of the system. Thanks to it, we can calibrate actions to be taken in order to minimize negative impacts and improve positive ones.

The process of *action calibrating* starts from the the temporal Diagram, that shows clearly the possible impacts on the aspects of the urban system and time horizons. In the selected case study, the diagram indicates the kinematic modality as driving in the future, this means that actions need to be taken in that direction.

Backcasting approach at this stage of the temporal analysis is immediate: the context has been built in a peculiar way, and actions for the future are "suggested" by the context itself. Thanks to this, backcasting is supported by a strong structure, and uncertainty is reduced.

4_Conclusions

Backcasting has been used in future studies since several decades; nevertheless, it is still popular, and its application is successful in many contexts.

This paper has presented three different applications at three different scales of the backcasting approach to urban discipline. All of them indicate that due to the increasing level of risk and uncertainty that characterize today's life, forecasting appears not to satisfy the present needs of planning for the future adequately. The main reason is that we act in an uncertain world, which requires planners, policy makers, and citizens to search for fixed points, instead of dwelling on images of possible but not certain futures. To reduce uncertainty in decision making is one of the main challenges for the future.

The target-oriented backcasting approach reflects the likely need for immediate action. Once decided what direction to take, we can start from a desired/necessary future and plan how to reach it.

If planning for the future means to know the future, the best we can do is improving common awareness today. It helps in having a wider vision of what is required today to have a possible future tomorrow. The Dooyeweerdian Temporal Analysis presented in this paper is a suggestion towards this direction. Be Backcasting a process *from the future back to the present for the future*, consciousness, responsibility and awareness of the present are keystones.

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THE BREAK-EVEN POINT

Impact of urban densities on value creation, infrastructure costs and embodied energy

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density
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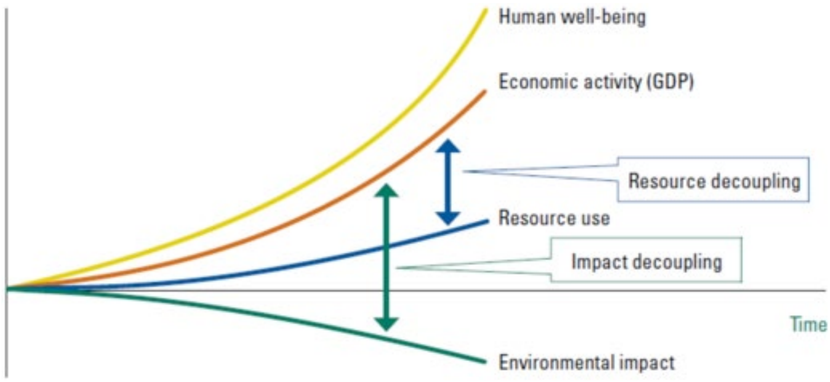
urban hierarchies
transit
land use

Abstract

This paper, based on the science of complex systems applied to cities, presents new findings on the impact of density on urban space economy: urban spatial expansion value added creation versus additional urbanization costs. The paper proposes a new metric, the hierarchy coefficient in Pareto distributions, to describe the distribution of densities across urban space. Based on case studies in London, Paris, New York, and a Chinese city, Zhengzhou, the paper reveals striking mathematical regularities, independent of the cities and their history, in the distribution of people, jobs, and energy densities within the urban space. This hidden order behind the apparent randomness of urban data points towards universality classes[1] in the organization of cities. These findings have important policy implications for coordinating land use, transport, and economic policies in particular by determining a break-even point beyond which urban expansion costs more than the derived benefits.

1_Decoupling

In economic and environmental fields, decoupling is becoming increasingly used in the context of economic production and environmental quality. When used in this way, it refers to the ability of an economy to grow without corresponding increases in environmental pressure. In many economies, increasing production (GDP) raises pressure on the environment. A "decoupled" economy is able to increase GDP growth while decreasing its negative impact on environment.



Decoupling human development and economic growth from escalating resource use and environmental degradation: Resource decoupling: less resource use per unit of output; Impact decoupling: less environmental impact per unit of output. Sources: International Resource Panel, Fischer-Kowalski, M., Swilling, M. (2011) Decoupling Natural Resource Use and Environmental Impacts from Economic Growth. Nairobi: UNEP

This paper describes how shaping residential and economic densities at metropolitan scale is a powerful policy lever for decoupling.

2_The Spiky Geography of Urban Productivity

2.1_The 80/20 Rule in urban spatial economics

The 80/20 Rule is observed in many social and economic phenomena. Vilfredo Pareto was the first to see in the early 1900s that 80% of Italy's land

[1] In statistical mechanics, a universality class is a collection of mathematical models, which share a single scale invariant limit. Here universality is seen as the fact that, despite their different socio-economic dynamics, these urban systems all adopt a similar scaling pattern with regard to the distribution of their densities across urban space.

was owned by only 20% of the population. More recently, Pareto's Law or Principle, known also as the 80/20 rule, has been turned into the Murphy's Law of management: 80% of profits are produced by only 20% of employees; 80% of customer service problems are created by only 20% of consumers; 80% of decisions are made during 20% of meeting time; and so on. The 80/20 Rule describes the same phenomenon: in most cases four-firths of our efforts are largely irrelevant. The 80/20 Rule structures social networks: 80% of links on the Web point only to 15% of Webpages; 80% of citations go to only 38% of scientists; 80% of links in Hollywood are connected to 30% of actors.

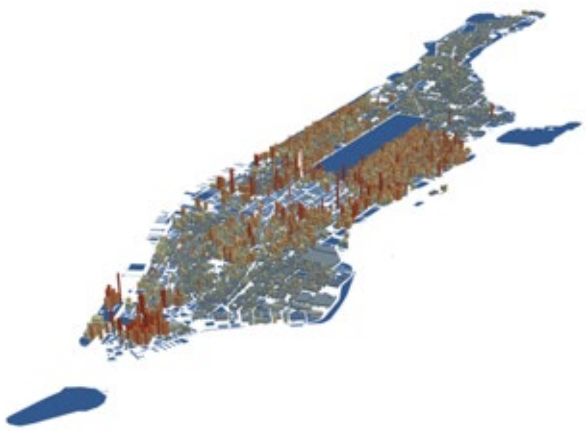
The 80/20 Rule structures also the global economy. Today only 600 urban centers generate about 60 percent of global GDP. Among these, the top 10 cities with 2% of the world population generate about 11% of the world GDP. Only one city at the top of the global economy, Tokyo, generates about 20% of the top ten cities cumulated GDP. The 80/20 Rules structures also intra urban economic space. Within a city, 20% of the urban land produces 80% of the city's GDP. Inner London with 20% of Greater London area produces 70% of its GVA[2] and concentrates 56% of all Greater London private sector jobs. This is due to strong agglomeration and localization economies.

[2] In 2009, Outer London produced 83 billion £ GVA and Inner London 186 billion £. Source: Regional and sub-regional GVA estimates for London, UK Office for National Statistics Briefing Note, 2009.

[3] One third of New York City and Greater London jobs (1.5 million jobs of these two cities of 8.5 million inhabitants) are concentrated in only 15 km^2 in each city while New York covers 790 km^2 and Greater London covers 1,572 km^2.

2.2_Bumpy and spiky economic landscapes

Urban productivity results from a complex interaction of processes, including economies of scale and economies of agglomeration and localization induced by cost savings, location advantages, specialization premiums, and by the higher intensity of interactions between people and companies. Agglomeration forces translate into bumpy and spiky urban economic landscapes. In competitive cities, such as London and New York, one third of the jobs are agglomerated in about 1% of the metropolitan area creating intense knowledge spillovers, while the other two-thirds are clustered around transit stations[3]. High densities of jobs increase productivity, competitiveness and job creation: 29% of Inner London office space is concentrated in less than 1% of its area, in the City of London (450,000 jobs in 2.9 km^2 with a growth of 30% during the last decade); 60% of New York City office space is concentrated in 9 km^2 in Manhattan, that is in about 1% of NYC area. These extreme concentrations peak at 150,000 jobs/km^2 and are made livable by high quality public space like in London's Canary Wharf or in the project of Hudson Yards in Manhattan.



Left: Residential FAR in Manhattan. Right: Office FAR in Manhattan. Office space in Manhattan (66 km^2) corresponds to 60 % of the entire New York City office space while NYC spans 780 km^2 of emerged land with 8.5 million inhabitants. This office space is concentrated in only 6 km^2 of plots, which roughly correspond to 9 km^2 of urban land. Source: Urban Morphology Institute.

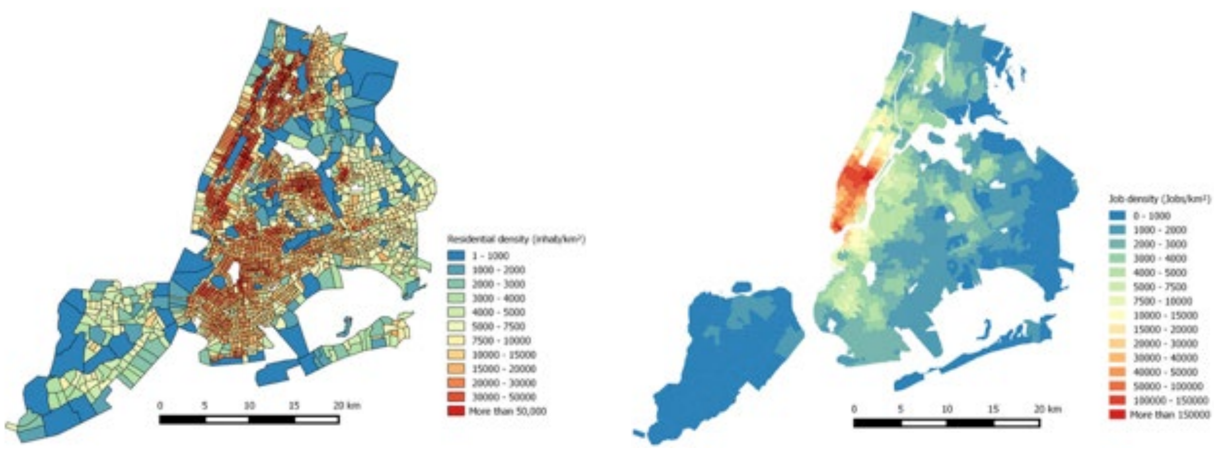
2.3_Pareto distributions: the hidden order of spiky economic landscapes

Within the high spike of wealth and economic might of Central London (309 km^2), the Square Mile of the City of London (2.9 km^2, 10% of Central London, 1% of Inner London, and less than 0.2% of Greater London) concentrates a disproportionate part of economic power in an extreme spike. The Square Mile of the City of London generates £45 billion in economic output in 2014, equivalent to 14% of London's output and 3% of the UK's total GDP. The cascade of spikes within spikes, The City of London spiking extremely high within the high spike of Inner London, points to a fundamental property of the 80/20 rule when applied to urban spatial economy: the rule applies at all scales; there is no characteristic scale; the rule is scale-free.

The new science of networks has shown that this scale free property is the intrinsic order to the number, size, and shape of the various attributes of networks (2). And then in turn there is an intrinsic order of spaces and places that depend on urban networks. As summarized by Michael Batty, "in essence, the distribution of elements that compose the city – the hubs or nodes that sustain them – present us with highly skewed distributions, reflecting the essential economic processes of competition that drive a city's functions and determine its form and structure (3)." These distributions usually describe large number of small objects and small number of large, following what are called scaling laws that, in turn, are usually configured as power laws, also called Pareto distributions in economy.

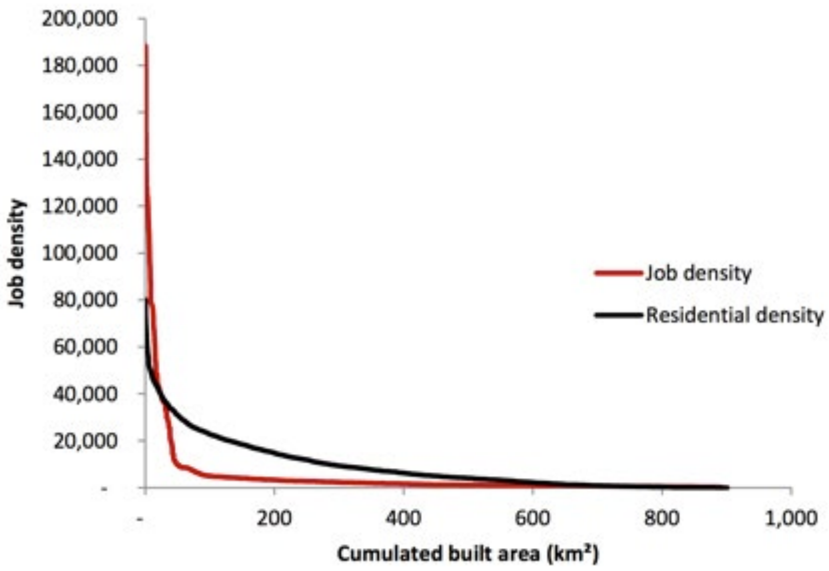
Power laws reflect processes that scale, that in some sense are self-similar, and this signature of a system's function implies that the system's subsystems, components, elements, are ordered hierarchically. These scaling processes generate urban growth and underpin the city's evolutionary architecture (3), opening up our theory and model of urban economy to the world of complexity theory, to forms that associate a high level of order in their macro-structure with a high level of diversity and randomness in their details.

Inverse power laws: the hidden order of spiky economic landscapes. People, jobs, and economic densities, office space density, accessibility to jobs, rents, subway network centralities, and so on, across the urban space (4) follow skewed distributions that are modeled by inverse power laws known in economy for a long time under the name of Pareto distributions. They comprise a few large and very large values (in green on the left) and a 'long tail' of small values on the right.



Left: The map of residential density in New York is aligned on the geography of transit accessibility to jobs. The higher the number of jobs a location has access, the more it is developed. Right: New York jobs are mainly concentrated in Midtown and in Lower Manhattan with densities above 150, 000 jobs per km² in these 2 economic engines of New York. Source: Urban Morphology Institute.

Densities in New York are articulated by power laws. Residential density in New York is extremely concentrated and aligned with the geography of transit accessibility to jobs, with a density above 18,000 people/km^2 on the densest 150 km^2.



The jobs density distribution across New York urban space follows a power law of hierarchy exponent -1 (in a rank size analysis) while office density is even sharper in its spatial hierarchy with a hierarchy exponent -1.7. Residential densities are distributed more evenly than jobs with a hierarchy coefficient of - 0.74. Source: Urban Morphology Institute.

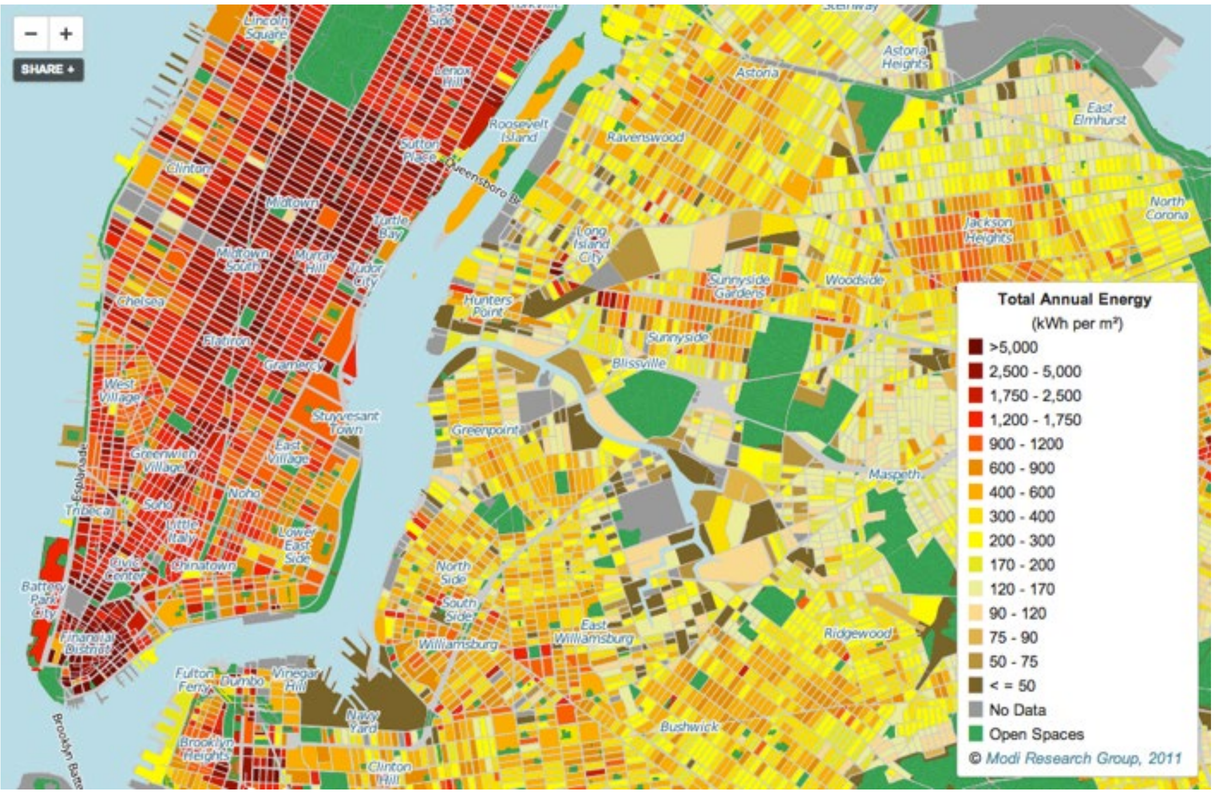
New York and London as well as Paris have the same distribution of jobs densities – a power law with an exponent -1 – which points towards what is called a universality class in physics, that is a convergence of different phenomena towards the same geometric structure. In statistical mechanics, a universality class is a collection of mathematical models, which share a single scale invariant limit. While cities, such as Paris, London, and New York, may differ dramatically at small scales, their behavior will become increasingly similar as the limit scale is approached. In particular, asymptotic phenomena such as critical exponents will be the same for all cities in the class. Studies of cities as percolation systems with phase transition points may explain these universality classes in urban systems.

3_The Spiky Landscape of Urban Energy

The spiky economic landscape translates into very high energy density spikes. The geography of energy consumption in competitive cities is extremely uneven, and this is an important key to energy efficiency as the highest spikes of energy density are also the highest spikes of economic density. Like the urban economy, the urban energy is scaling according to Pareto distributions. Urban GDP and urban energy consumption/unit of urban land are highly concentrated in peaks in the cores of global cities while peripheries are less energy intensive but produce much less added value. The ratio of added value to energy inputs measures the different energy productivities across the urban space. The bumpy and spiky distribution of both energy consumption and value added per unit of land has important consequences for the choice of modes of decentralized energy supply, which varies between high energy intensity centers and low energy intensity peripheries.

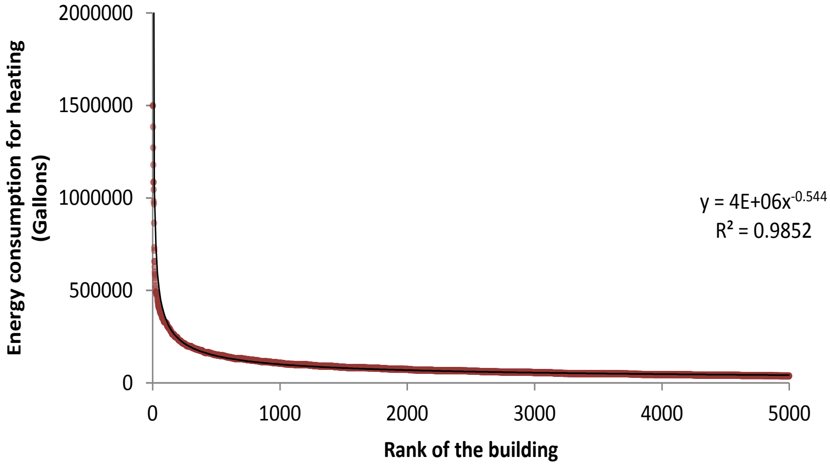
3.1_The hidden order of urban energy landscapes

NYC energy landscape presents a high level of variation at each scale, from NYC scale (780 km² of emerged land), to block scale, and to fiscal plot scale (200 m²). It is a scale-free landscape with no characteristic average value for the energy use on a plot of land. These energy density variations of 100-fold within the same city matter and have strong impacts on the possible types of energy mix in each neighborhood. A power law orders the energy densities in New York. This is the signature of a scale free distribution of energy consumption across the urban space.



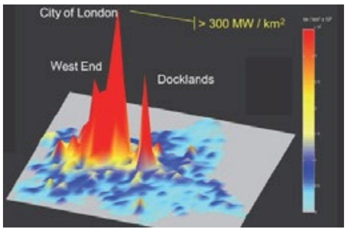
The map represents an estimate of the total annual building energy consumption at the block level and at the tax lot level for New York City, and is expressed in kilowatt hours (kWh) per square meter of land area. A mathematical model based on statistics, not individual building data, was used to estimate the annual energy consumption values for buildings throughout the five boroughs. Map created by Shaky Sherpa of Sustainable Engineering Lab (formerly Modi Research Group. Data Source: Spatial distribution of urban building energy consumption by end use B. Howard, L. Parshall, J. Thompson, S. Hammer, J. Dickinson, V. Modi.

Heating energy by building in NYC. The energy consumption is ranked from the highest consuming large-scale office towers (on the left) to the long tail of residential houses (on the right). The distribution describes both the scale free structure of NYC urban fabric (here described by buildings) and the scale free structure of NYC building's energy consumption across the urban space. Source: Urban Morphology Institute



3.2_Spikes of economic density and energy correspond to higher energy efficiencies

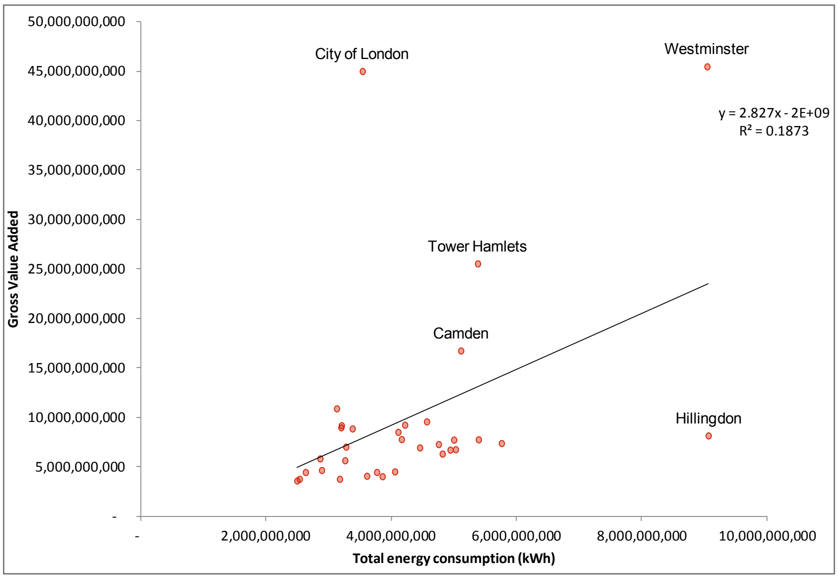
As shown in the maps, London's energy and economic landscapes reflect each other with peaks of high concentrations in the City of London and the Docklands (Canary Wharf).



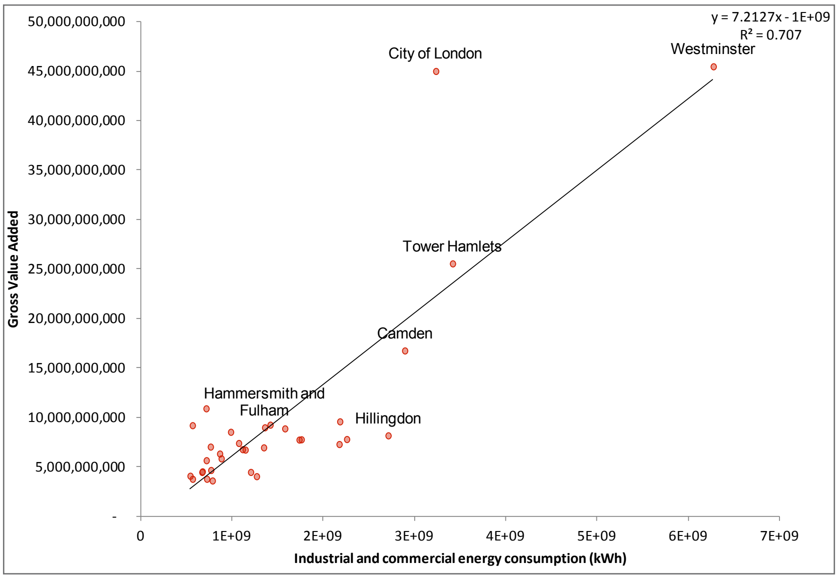
London energy landscape is characterized by a high spike of energy density (here electricity per unit of land) of more than 300 MW/km² in the City of London.

Distribution of workplace densities in London, using Census Output Areas, with a peak of 150.000 jobs per km² in the Square Mile of The City of London. Source: Urban Morphology Institute.

The following charts show that in terms of energy productivity (GVA/E), the City of London stands out due to its agglomeration economies and specialization.



GVA and total energy consumption in London boroughs. Source: Urban Morphology Institute.



GVA and industrial and commercial energy consumption in London boroughs. Source: Urban Morphology Institute.

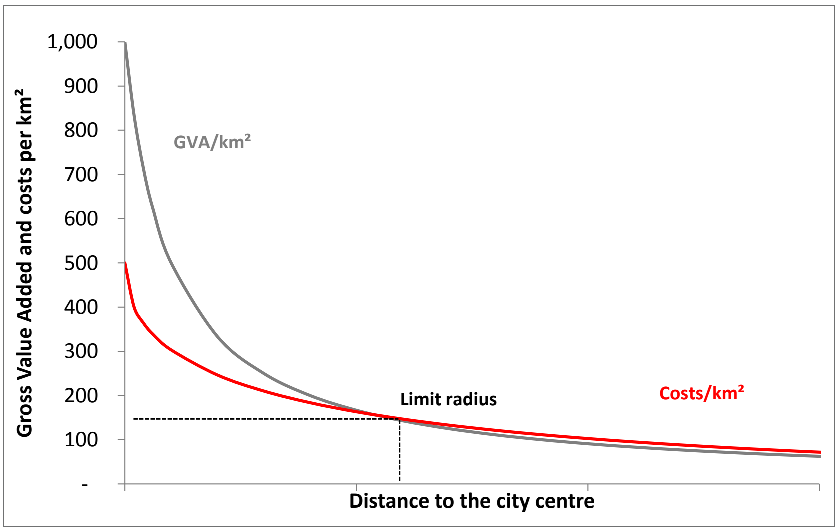
4_The Break-even Point

In economics and business, specifically cost accounting, the break-even point (BEP) is the point at which cost or expenses and revenue are equal: there is no net loss or gain, and one has "broken even." Understanding the hierarchies in GDP creation across the urban space and the variations of costs of networks across urban space, allows determining a break-even point. There is a limit radius where further spatial expansion at low density produces less value added than it costs in infrastructures.

Our empirical research has shown that urban GDP is, like jobs densities, distributed according to a Pareto principle with 20% of urban land producing 80% of urban GDP while 80% of the urban land produces only 20% of the GDP. This is verified with the differences in GDP between Inner London and Outer London, and has been verified under the form on an inverse power law of exponent -1 in a detailed study of Zhengzhou in China and is more broadly confirmed by the universal power law with an exponent close to -1 that organizes the distribution of jobs densities in the urban space in Paris, London and New York. The Pareto structure of urban economic space derives from two combined self-reinforcing effects: the Pareto distribution ordering jobs distribution across the urban space and the higher productivity per job in the left part of the Pareto curve because of strong agglomeration economies in this left part. Urban GDP follows a power law of exponent about - 1.

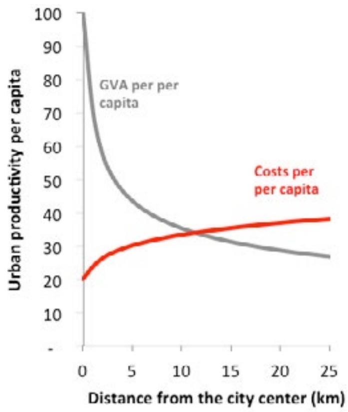
Networks lengths/km² and costs/km² decrease also with urban expansion because of their fractal nature but more smoothly (6) (7) (4). They decrease at the power - 0.5 for subway systems, due to the core and spokes structure of these networks (4), and more generally with a scaling exponent depending on the fractal nature of the specific network (3).

Thus as GDP decreases more sharply than infrastructure costs with spatial expansion, beyond a certain radius, infrastructure lengths and costs (and embodied energy in infrastructures) become higher than additional economic output. As a result, urban land is less and less economically productive and more and more costly in terms of infrastructures, and embodied material and energy when moving away from the urban core. This pattern is captured in the following charts.



GVA/km² versus infrastructure costs/km². Source: Urban Morphology and Complex Systems Institute based on international benchmarks of infrastructure costs per km² linking urban density and pavement costs, water network costs, waste water network costs (1) (5).

The decrease in densities when moving away from the urban core induces also higher infrastructure costs per capita. The following chart describes the relationships between economic productivity (measured per capita) and infrastructure costs per capita.
Sprawl is thus a highly inefficient pattern where costs become higher than economic benefits after a break-even point. Sprawl is central to our wasteful use of water, energy, and land. To move from sprawl toward more compact urban forms, urban connectivity and density must be intensified through changes in regulatory urban planning. Increasing densities around transit nodes will foster energy and resource productivity, decoupling urban economic growth from infrastructure costs and energy embodied in infrastructures.



GVA and costs per capita across urban space. Source: Urban Morphology and Complex Systems Institute.

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MANAGEMENT STRATEGIES FOR THE ENERGY SAVING OF PUBLIC BUILDINGS THROUGH A DECISION SUPPORT SYSTEM

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Abstract

The OPTIMUS Decision Support System (DSS) developed within the FP7-Smatcities project OPTIMUS is a web-based tool addressed to city authorities to assist them in the decision making process, aimed at minimizing both energy use and CO_2 emissions in public buildings. The OPTIMUS DSS receives input data belonging to different fields (weather, in-building sensors, social media, energy costs and energy production). The elaboration of these heterogeneous data through data mining techniques and inference rule processing provides to the stakeholders a set of actions regard the management of the HVAC systems, to be implemented within a week. The actions include the optimal start/stop of the heating system, the schedule of the indoor set point temperature according to the adaptive comfort concept and to real time feedback of the building occupants, the management of the air-side economizer, the load shifting related to the self consumption/selling of the energy produced through a PV system.

The paper describes the architecture of the OPTIMUS DSS with particular regard to the modelling process of the actions. An example of action plan process is also presented and the first results are discussed.

1_Introduction

Several stakeholders are involved in the management of the existing public buildings aimed at decreasing the energy consumption without compromising comfort for occupants. To facilitate this task, web-based tools for monitoring and controlling the building appliances through a sensor network are becoming more and more common.

Until now, BEMS (*Building Energy Management Systems*) or BACS (*Building automation control systems*) are used for the building management. Similar software, based on a wired or wireless network of sensors, using data elaboration process and prediction models, are the so called Decision Support Systems (DSS). Unlike the BEMS or BACS, a DSS does not provide a real time feedback but gives a short time (e.g. weekly) support to an expert (the energy manager typically) that is free to decide whether to accept a suggestion or not. The presented DSS provides both suggestions at single building level and at district level. Moreover, it processes the data coming from different kind of sources: building sensors, weather database, energy prices, renewable energy (RES) production and feedback from occupants. Unlike a BEMS, the DSS gives suggestions about the management of the building occupants and considers both their reassignment (to better schedule the HVAC system operation) and the load shifting (to better manage the on-site RES production). A higher level of responsibility is given to the persons involved in the management process as well as to the building occupants.

This tool is being developed within the FP7-Smartcities Project OPTIMUS (*OPTimising the energy Use in cities with smart decision support system*). The paper describes the design of the software architecture and the data processing which precede the development of the DSS engine. The next activity will concern the testing of the models and the application of the action plans to four pilots in Savona (Italy), Zaanstad (Netherlands) and Sant Cugat (Spain).

The software and the stakeholders involved in management process are here described; the suggested management strategies are described and an example of action plan is also given.

2_Description of the OPTIMUS DSS and involved stakeholders

The OPTIMUS DSS may be addressed to two kinds of actor: the building manager and the building occupants. The building manager can be either internal or outsourced or even an energy service company. His duties can be summarised as follows:

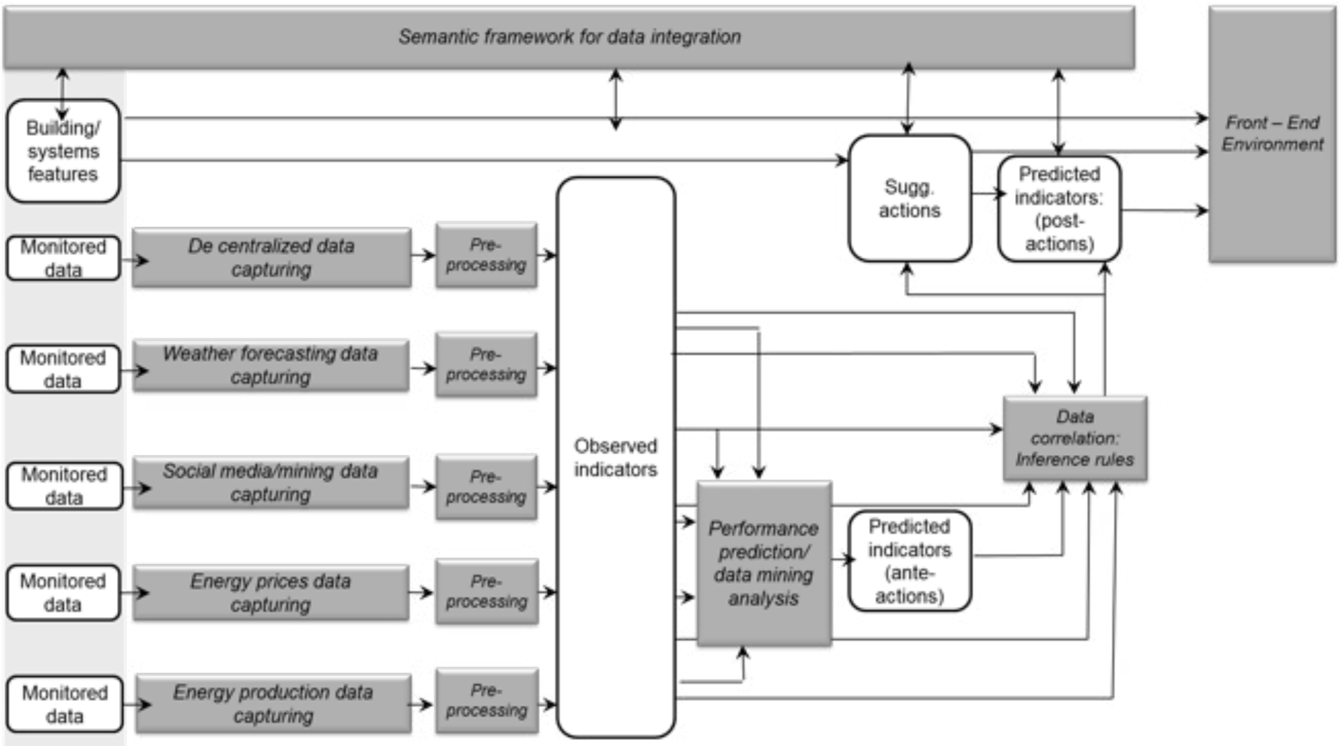
- Providing services to the buildings with regard to their cost
- Managing the maintenance of the building structures
- Controlling/managing the setting of the heating/cooling/ventilation systems
- Establishing the comfort level of the inhabitants

Also the occupants of the buildings are involved in the application of the DSS, since their participation is needed to implement the set of action plans as described in the next sections.
The occupants may be involved in the following activities supervised by the building manager:

- Actively participating in the building management by informing the building manager about malfunctions or faults
- Modifying their behaviour by the adoption of different actions to reduce energy consumption on one hand and to maintain the comfort level on the other hand.

The OPTIMUS DSS architecture is described in Figure 1. The software includes five data capturing modules from different sources (sensors, web platform, existing Building Monitoring Systems) and different fields. The DSS

Figure 1. Overall architecture of the OPTIMUS DSS.



engine then processes the data using predictive models (black box, grey box and simplified white box approach) and proper inference rules.
An inference rule is an expert knowledge-based rule that can be expressed in a logical form (if-then), with a graphic expression (flow-chart, table etc.) or as a mathematical equation. The inference rules allow to process the input data, both predicted and monitored, as shown in Figure 1, and to supply the actions, which are the main output of the entire process.
To develop the predictive models and the inference rules for the specific pilots, real data have been used for the training and the testing of the models. The same models are also supposed to be adapted in buildings with different kinds of technical systems and different boundary conditions.

3_Management strategies for the energy saving

The main DSS output is a set of action plans to be implemented during the week ahead.
The building manager receives the action plan suggestions in the form of daily messages, which are visualized through a user interface. The action plan may concern a whole building, a part of a building or a group of buildings. The building manager decides if the suggested action for the week ahead is worthwhile to be carried out or not.
The following list of the action plans is implemented in the DSS, as shown in Figure 2:

- Action Plan 1 aims at reassigning the building occupants and scheduling the HVAC start/stop at zone level.
- Action Plans 2 and 3 refer to the management of the heating and cooling systems both by calculating the optimal daily boost time to minimize the energy consumption, and determining the indoor set point temperature through an adaptive comfort approach and feedback from occupants.
- Action Plan 4 refers to the scheduling of the air side economizer and introducing a demand control ventilation strategy when a low percentage of occupancy occurs.
- Action Plan 5 introduces a fault detection strategy for the PV system: a message is sent through the DSS whenever the possibility of malfunction of the PV system is identified.
- Action Plan 6 regards a demand side management strategy through loads shifting at building level as to optimize the PV performance. According to this strategy, different scenarios can be chosen: a green strategy if the purpose is to reduce the energy consumption and the CO_2 emission; a finance strategy if the aim is to minimize the energy cost; a peak strategy if the purpose is to smooth the energy demand profile.
- Action Plan 7 is related to the activation of a peak shaving strategy whenever an energy storage is present and the choice of the energy source to cover the demand, considering battery charging, RES production and energy from the grid. This action may be developed both at building level and at district level, whenever a smart grid is present.

As shown in Figure 2, each action plan may be the result of one or more inference rules. For example, as regards the management of the heating and

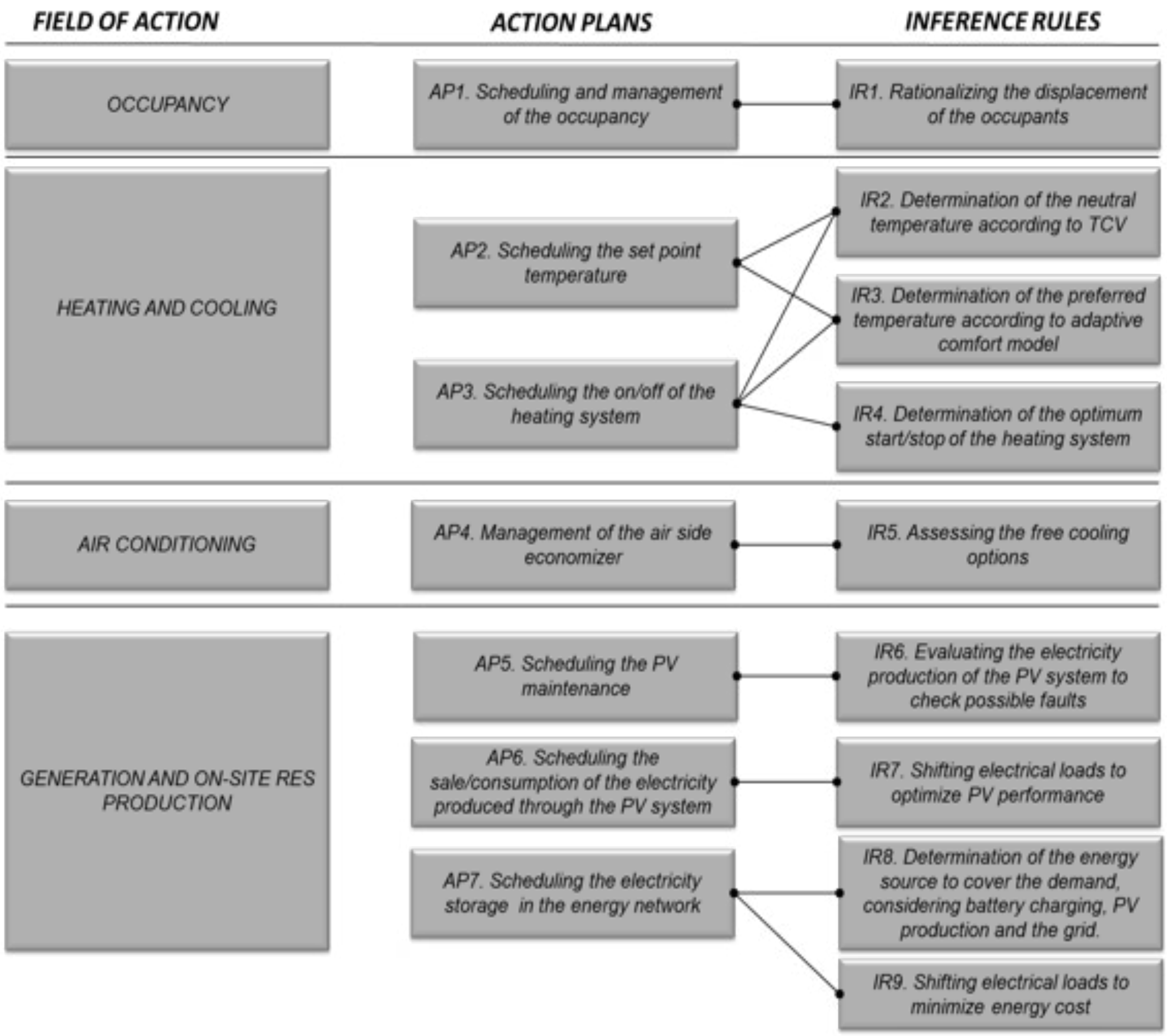


Figure 2. List of the action plans and correlation with the inference rules.

cooling system, the related action plans schedule the operational time of the heating system for the week ahead and/or schedule the set point temperature. These action plans are interrelated and come from three inference rule processes. The setting of the indoor temperature derives from two interrelated inference rules based on adaptive comfort model and on comfort feedbacks from the occupants.

All the actions are interrelated as shown in Figure 3. First of all, the reassignment of the building occupants affects the HVAC start/stop scheduling and influences the air conditioning management too, since a demand control ventilation is a function of the occupancy profile. Also the heating/cooling system operation is connected to the management of the air side economizer since the input data for the management of the economizer are both the set point temperature of a zone and the on/off switching of the system. The energy demand of the building zone affects Action Plan 6, which allows to schedule the sale/consumption of the electricity produced through the PV system and to suggest the possible load shifting. The output of this rule in term of load shifting ultimately affects the occupancy management.

Action Plan 7 is also affected by the scheduling of the heating and cooling system since the energy demand is needed for the implementation of the rule.

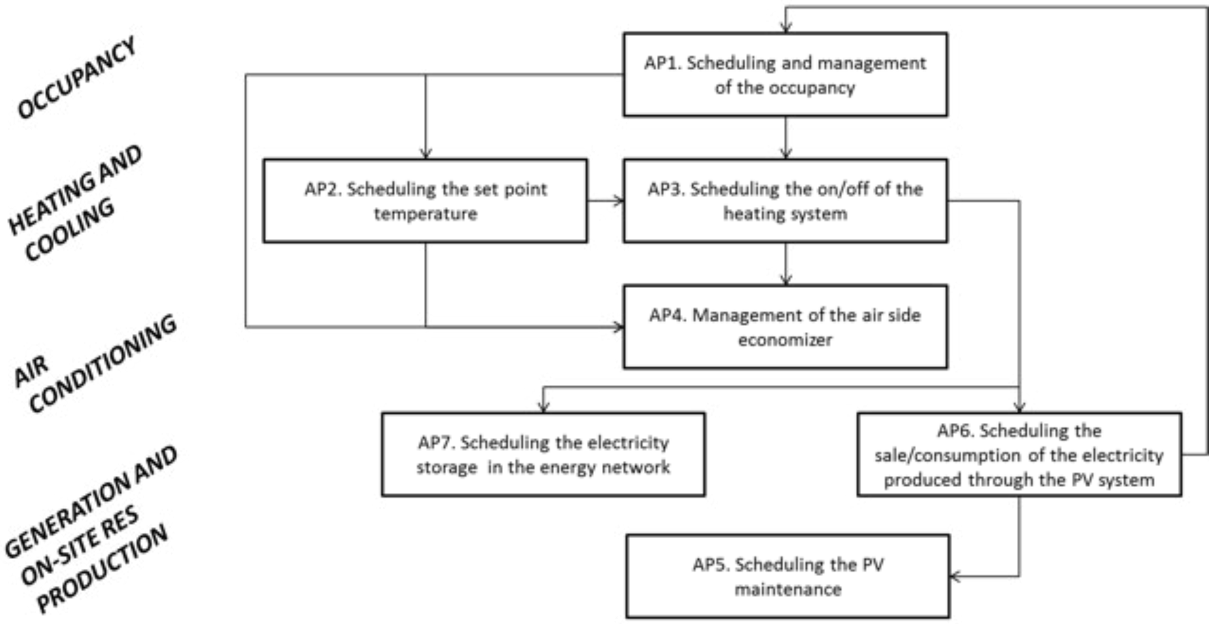


Figure 3. Connection among the action plans.

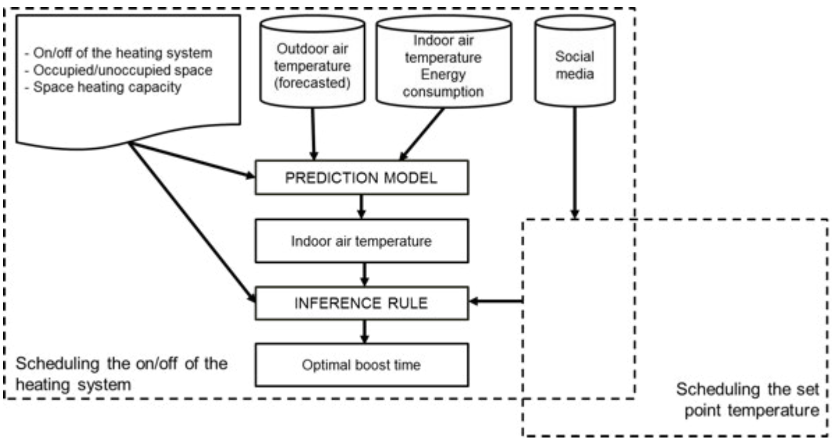
4_Description of the action plan modelling

An action plan process includes the following parts:

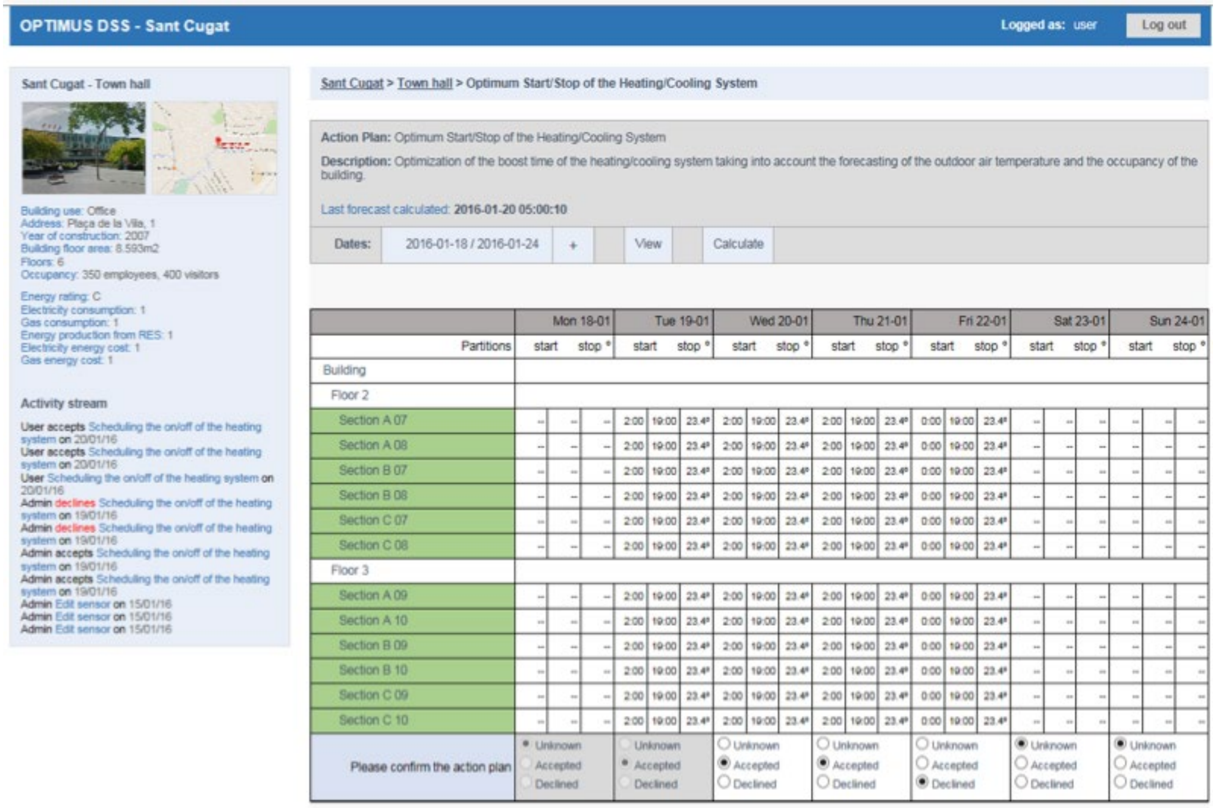
- Dynamic and static input data, collected by the capturing modules
- Predictive model to provide hourly profiles for the week ahead (implemented in the DSS engine)
- Inference rule to elaborate both the captured data and data processed by the predictive models.

An example of the action plan modelling, regarding the scheduling of the on/off of the heating system, is shown in Figure 4.

Figure 4. Modelling of an action plan.



An example of the output of an action plan, visualized though the DSS user interface, is shown in Figure 5. In this example, for each building zone that can be managed separately, the DSS suggests an on/off schedule for each day of the following week. This action plan is also influenced by the action plan related to the scheduling of the set point temperature.



The following sections describe all the management strategies provided by the DSS.

Figure 5. Example of user interface for a pilot and for the action plan concerning the scheduling the on/off of the heating system.

4.1_Scheduling and management of the occupancy

This action is aimed at reducing the building energy consumption through the zone assignment of the occupants in such a way as to use the minimum number of thermal zones, by considering the ranking of energy need for each of them, the predicted thermal comfort and the occupant's profiles.
The building energy use can be reduced by applying a HVAC start/stop schedule based on the occupied thermal zones and occupancy profile. The heating/cooling system should be turned off when the zones are estimated to be empty or be turned on when the occupants enter into the zone. Moreover, since the zones may have different occupancy patterns, the occupants with similar profiles or similar job tasks may be located in the same zones to unify the start/stop times. An example of this action plan is given in section 5.

4.2_Management of the HVAC systems

The management of the HVAC regards Action Plans 2, 3 and 4.
The scheduling of the on/off operation of the heating system aims at optimizing the boost time. Specifically, the aim of this action is to optimize the boost time taking into account the forecasting of the outdoor air temperature and the occupancy profile of the building.
A predictive model based on a grey box approach is used to predict the indoor air temperature trend and to calculate the optimal boost time. It considers that the heating system operates in a normal heating mode when the building is occupied, in a cut-off or a set back temperature mode when the building is unoccupied and in a boost mode to reach the set point temperature.

This action plan is correlated with the setting of the indoor temperature to optimize the energy use and maintain the comfort levels in acceptable ranges. The set point temperature can be scheduled according to the adaptive comfort theory and to recent international research investigations. A regression equation schedules the indoor set point temperature as a function of the outdoor mean running temperature.
Since the occupants of the building are important actors of the management process of the building, they are asked to provide feedback to the DSS in term of thermal comfort sensation. A specific application named Thermal Comfort Validator has been developed to translate a qualitative input parameter from the occupants (cold, hot, etc.) into the PMV index.
Another action aimed at reducing the energy consumption of the building is focused on the air conditioning system and on the possibility to operate with an air side economizer. The action suggests to use outdoor air to reduce or eliminate the need for mechanical cooling when outdoor-air conditions are favourable.
Moreover the air side economizer strategy can be coupled with a demand control ventilation strategy: the ventilation can be reduced during the hours of operation when zones are vacant or occupied lower than the design occupancy.

4.3_On-site RES production

The management of on-site RES production is carried out through Action Plans 5, 6 and 7. These action plans and the relative inference rules are aimed to optimize the exploitation of the energy produced by PV considering that it can significantly contribute towards cost effective energy management.
The aim of Action Plan 5 (see Figure 2) is to ensure a robust operation of a PV plant through a frequent maintenance as to avoid a decreasing of efficiency that may result to limited energy production, decreased incomes and deviations from CO_2 emissions targets. Through the use of a proper model, it is possible to detect the need for maintenance and to predict the correct expected energy produced by PV in different boundary conditions. The deviations between the real-time monitored values of production and the expected values are used to detect the opportunity to check the system for maintenance.
Action Plan 6 allows to improve the exploitation of solar energy providing a schedule of the sale/consumption of electricity produced by the PV system for the week ahead. The relative inference rule is aimed at maximizing the self-consumption of electricity produced on-site, and to take advantage from the selling of the surplus of energy produced considering the forecasted energy prices. In addition demand side management strategies consisting in the shifting of some electrical loads can be considered and coupled in the optimization criteria. This coupling is useful to assure that energy demand does not fall below PV-production when it is more convenient to use the energy (maximize the self-using of PV energy) or to create surplus of energy (by means of load shifting strategies) when it is convenient to sell the energy produced through the PV system.
Action Plan 7 is linked to Inference Rules 8 and 9. Inference Rule 8 allows buildings with hybrid systems to optimize the energy flow from/to the batteries and their selling/buying strategy to/from the grid. In case of surplus of

energy production and absence of peaks, the inference rule suggests the energy flow to the battery and its selling to the grid. In the other cases, battery is charged and discharged accordingly in order to minimize the energy cost based on the forecasted energy price. Inference Rule 9 detects cost shaving opportunities considering charging policy of the electricity supplier and the predicted energy demand and prices of the upcoming week. The output of the rule is a schedule for redistributing loads so that the adjusted demand sums up to the predicted one but leads to a more economical solution, mainly due to reduced (shaved) peaks.

5_Example of OPTIMUS strategy

An example of the strategy related to the reassignment of the building occupants is given. This action plan is going to be applied in the Town Hall of Zaanstad (Netherlands). In this building the employees can be freely displaced according to the rule since they have no personal offices (i.e. they have not a fixed working-position).

The rule aims to displace the building occupants as to occupy the minimum number of thermal zones according to their maximum capacity and, when it is possible, the building zones with the lowest estimated energy consumption.

To implement this inference rule, a previous analysis has been developed to:

- Estimate the energy consumption of each thermal zone and introduce an energy ranking for each of them.
- Discover the most representative daily occupancy profiles for a standard week using an elaboration process based on cluster analysis.
- Define a supervised process in order to classify the representative occupancy profiles using the most consistent attributes.

The energy consumption has been estimated through a simplified white model approach based on the monthly method of the Technical Standard EN ISO 13790:2008.

The yearly energy need for heating and cooling of each zone is then associated with each building zone in the DSS. This calculation procedure allows the building zones to be ranked according to their energy need for space heating considering a standard use of the building.

In Figure 6 the three building zones of the Zaanstad Town Hall are shown together with their calculated energy rating. Since the zones are similar in

Figure 6. Building plan of the Zaanstad Town Hall with the indication of the building zones and their energy rating.

term of thermal properties and geometry of the envelope as well as in term of orientation, only a slight difference among their energy need for space heating was observed.

The total hourly number of occupants for a period of two months (related to the three thermal zones) was analysed with the aim to define typical occupancy profile for each day. A k-means clustering algorithm was then applied to group the similar daily occupancy profiles (24 values of occupation rate for each day). Considering appropriate metrics (e.g. Davies-Bouldin index, Sum of Squares Error), a number of four cluster was found as the best partitioning value for the analysed dataset. For each of the four clusters the centroid (defined as the profile composed by the average values of the occupancy rate for each hour) was considered as the representative occupancy daily profile for the building. A sensitivity analysis on the four representative profiles (the centroid of each cluster) allowed to discover that the day of the week is a variable with a strong relation with the identified patterns. For this reason, this variable was selected as the most suitable attribute for the development of the classification process. To this purpose, a Classification tree (CART) was developed using as response variable the representative pattern related to each cluster and as attribute the day of the week.

The CART model provides splitting criteria to univocally identify the reference pattern in the different days of the week. The results show that each pattern can be associated with a low level of uncertainty to a specific group of working or not-working days. In particular a typical profile for Saturday and Sunday, one for Friday, one for Wednesday and one for the remain weekdays was identified.

Figure 7 shows the application of the inference rule. Firstly, for each day of the week, the classified typical profile, allowed to identify the number of occupants in different part of the day. In particular, the maximum value of occupants for each part of the day was extracted with the aim to summarize the profile through the DSS interface. The values extracted for the morning and afternoon period (9:00-17:00) are compared with the maximum capacity of each thermal zone in order to select the minimum number of the thermal zones to be taken open according to their energy need. As shown in Figure 7 on Monday, Tuesday and Thursday the estimated maximum number of occupants is higher than the sum of the capacity of the two largest zone. This means that all the occupants need to be displaced in all the three zones. Instead, the group of hours of the early morning is characterized by an occupancy much lower than the capacity of each zone. For this reason it is possible to displace the occupants according to the time arrival at the workplace in a single thermal zone with the best energy rating. The set-point temperature needs to be guaranteed accordingly. The zone EF and the Zone CD will be filled when the expected number of occupants overcomes the capacity of the first occupied zone. During these days the turning off of the HVAC system is scheduled at the same hour for the three zones when the expected occupancy is estimated to be null.

During Wednesday and Friday, instead, a thermal zone can be closed following the same reasoning above described.

			Monday			Tuesday			Wedsnesday			Thursday			Friday			Saturday			Sunday		
Building partitioning		Part of the day	Estimated occupancy	Constraints Yes/No	On/off	Estimated occupancy	Constraints Yes/No	On/off	Estimated occupancy	Constraints Yes/No	On/off	Estimated occupancy	Constraints Yes/No	On/off	Estimated occupancy	Constraints Yes/No	On/off	Estimated occupancy	Constraints Yes/No	On/off	Estimated occupancy	Constraints Yes/No	On/off
Building	Early morning 1	6:00 - 7:00	2			2			2			2			2			1			1		
	Early morning 2	7:00 - 8:00	186			186			160			186			114			1			1		
	Early morning 3	8:00 - 9:00	478			478			411			478			290			1			1		
	Morning - afternoon	9:00 - 17:00	597			597			503			597			376			2			2		
	Late afternoon 1	17:00 - 18:00	166			156			150			166			67			1			1		
	Late afternoon 2	18:00 - 19:00	30			30			25			30			15			1			1		
Zone C-D	Early morning 1	6:00 - 7:00	0		-	0		-	0		-	0		-	0		-	0		-	0		-
	Early morning 2	7:00 - 8:00	0		-	0		-	0		-	0		-	0		-	0		-	0		-
	Early morning 3	8:00 - 9:00	0		-	0		-	0		-	0		-	0		-	0		-	0		-
	Morning - afternoon	9:00 - 17:00	42		set point	42		set point	0		-	42		set point	0		-	0		-	0		-
	Late afternoon 1	17:00 - 18:00	0		set point	0		set point	0		-	0		set point	0		-	0		-	0		-
	Late afternoon 2	18:00 - 19:00	0		turn off at 19:00	0		turn off at 19:00	0		-	0		turn off at 19:00	0		-	0		-	0		-
Zone E-F	Early morning 1	6:00 - 7:00	0		-	0		-	0		-	0		-	0		-	0		-	0		-
	Early morning 2	7:00 - 8:00	0		-	0		-	0		-	0		-	0		-	0		-	0		-
	Early morning 3	8:00 - 9:00	207		set point	207		set point	140		set point	207		set point	19		set point	0		-	0		-
	Morning - afternoon	9:00 - 17:00	284		set point	284		set point	232		set point	284		set point	105		set point	0		-	0		-
	Late afternoon 1	17:00 - 18:00	0		set point	0		set point	0		set point	0		set point	0		set point	0		-	0		-
	Late afternoon 2	18:00 - 19:00	0		turn off at 19:00	0		turn off at 19:00	0		turn off at 19:00	0		turn off at 19:00	0		turn off at 18:00	0		-	0		-
Zone G-H	Early morning 1	6:00 - 7:00	2		-	2		-	2		-	2		-	2		-	1		-	1		-
	Early morning 2	7:00 - 8:00	186		set point	186		set point	160		set point	186		set point	114		set point	1		-	1		-
	Early morning 3	8:00 - 9:00	271		set point	271		set point	271		set point	271		set point	271		set point	1		-	1		-
	Morning - afternoon	9:00 - 17:00	271		set point	271		set point	271		set point	271		set point	271		set point	2		-	2		-
	Late afternoon 1	17:00 - 18:00	166		set point	166		set point	150		set point	166		set point	67		set point	1		-	1		-
	Late afternoon 2	18:00 - 19:00	30		turn off at 19:00	30		turn off at 19:00	25		turn off at 19:00	30		turn off at 19:00	15		turn off at 18:00	1		-	1		-

Figure 7. Visualization of the Action Plan "rationalizing the displacement of the occupants" (Zaanstad Town Hall).

6_Conclusion and future work

The OPTIMUS DSS can be a useful tool to support the building manager in defining the management strategies and reducing the building energy consumption without compromising the occupant comfort.

The general architecture of the OPTIMUS DSS has been defined and the set of suggested action plans have been developed and implemented in the DSS engine.

Each action plan is going to be applied in the above mentioned pilots and the impact analysis will be carried out within the end of the project.

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Sustainable Districts: Case Studies

SUSTAINABILITY OF SPORTS FACILITIES

Criteria and Case Studies

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Abstract

Up to now, a holistic methodology for the sustainability assessment of sports facilities is not available. Therefore, this paper presents a methodology developed specifically for the building typology sports facilities and shows the results of a case study. It is demonstrated how some of the developed 36 criteria address the specific characteristics of sustainable sport halls by their sub-indicators on the example of a sport hall in Southern Germany. The presented methodology, so far developed for stadiums and sports halls, may be a driver of sustainable building regarding sports facilities in the future.

1_Introduction

In recent years, assessing the sustainability performance of buildings became a common practice in today's construction industry. Labels like LEED, BREEAM or DGNB are widely used to assess the performance of an even wider range of building types such as offices, hotels, residential and educational buildings. However, up to now a holistic assessment methodology for the sustainability performance of sports facilities is not available, although the organisers of mega sport events are under constant pressure to report on the sustainable performance of their venues. Previous methods like the "BREEAM for Olympic Park and Venues" developed by BRE for the Olympic Games in London did not offer a holistic methodology (Essig, N., Gantner, J., Magdolen, S., 2012) and a comparison of the sustainability performance for sport facilities is not yet possible.
Therefore the objective of the present paper is to show a set of criteria and detailed indicators designed specifically to assess the sustainability performance of sports facilities for different applications: stadiums and sports halls. The methodology is developed by a joint German and Austrian working group under the initiative of the Austrian Sustainable Building Council (ÖGNI) and the German Sustainable Building Council (DGNB). Accordingly, the study considers Austrian and German standards as well as guidelines from associations and federations. There have also been previous studies by the authors which have been taken into account, such as the dissertation "Sustainability of Olympic Venues" that was published in 2010 (Essig, N., 2010) and the research project "Guidelines for Sustainable Venues of Mega-Events" that was supported by the BMWi (Federal Ministry for Economics and Technics) from 2012 to 2013 (Essig, N., Hiebel, M., Schneider, S., Jäger, M., 2012). To demonstrate its suitability for the application, several case studies have been conducted and examples of the "Sporthalle Zorneding" are shown in this paper.
In summary, the contribution of this study is obvious as the resulting outcomes can be applied for assessing the sustainability performance of sports facilities.

2_Methodology

First step of the study was to determine the main criteria for the sustainability assessment for sports facilities. A working group was established to investigate all different approaches for building sustainable sports facilities.

Property owners, architects and planners, representatives of associations and federations, political and economic representatives, researchers as well as members from the DGNB and ÖGNI took part in defining the set of criteria. Furthermore, subindicators were designed for the application to stadiums (type I) and sports halls up to 200 spectators (type II). The subindicators were developed by the experts from the specific sectors of the working group as well as the planners of the case studies to ensure the direct application.

2.1.1_Defining the Main Criteria

First step of the study was to determine the set of indicators for the sustainability assessment for sports facilities. A working group for sustainable sports facilities named 'AG Sportstätten' under the lead of Prof. Natalie Essig was established to investigate all different approaches for buildings sustainable sports facilities: Property owners, architects and planners, representatives of associations and federations, political and economic representatives, researchers as well as members from the DGNB and ÖGNI took part in defining the set of criteria.
The DGNB six pillars model was chosen because it covers all categories of sustainability in regard to buildings.

Figure 1. Sustainability categories, six pillars model (Essig, N., Hiniesto Munoz de la Torre, D.).

Besides previous studies by the authors (Essig, N, 2010 and Essig, N., Hiebel, M., Schneider, S., Jäger, M., 2012), the defined set of indicators was based on existing schemes for assessing the sustainability performance of different building types as shown in table 1.

Table 1. Certification Schemes analysed.

Certification Scheme	Developed by	Published in
DGNB Core for Offices (international use)	DGNB	2014
DGNB for Assembly Buildings	DGNB	2012
DGNB for Retail	DGNB	2015
DGNB for Hotels	DGNB	2015
DGNB for Offices	DGNB	2015
DGNB for New urban districts	DGNB	2012
DGNB for Education facilities	DGNB	2015
Buildings in Europe	OPEN HOUSE Consortium	2013
LEED Core and Shell	U.S. Green Building Council	2013
BREEAM for Olympic Park and Venues	BRE Global Limited	2011

2.2_Defining the Subindicators

After defining the criteria they were divided into subindicators. For most of the indicators, it was separated between the application to stadiums (type I) and sports halls (type II) due to different scales and approaches as well as guidelines. As mentioned before, type II refers to sport halls up to 200 spectators. The subindicators were developed by the experts from the specific sectors of the working group as well as the planners of the case studies to ensure the direct application. The authors guided through the working process as working group leaders and insured the quality of the project.

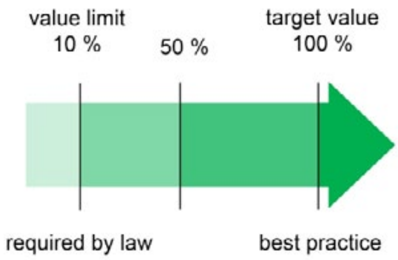
For utilizing the method in Austria as well as Germany, Austrian and German standards have been taken into account. Whereas for example office buildings have to fulfil requirements regarding lighting, temperature and ventilation according to the German 'Technische Regeln für Arbeitsstätten (ASR) (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, 2015), the normative requirements for sports halls in Germany are given with the DIN 18032 'Sports halls - Halls and rooms for sports and multi-purpose use' (DIN 18032-1:2014-11). Moreover, guidelines from associations and federations such as

- International Federation of Association Football (FIFA)
- and Union of European Football Associations (UEFA)
- as well as Deutscher Olympischer Sportbund (DOSB),
- Deutscher Fußball-Bund (DFB)
- and Österreichischer Fußball-Bund (ÖFB),
- Bundesinstitut für Sportwissenschaft (BISp)
- and Österreichisches Institut für Schul- und Sportstättenbau

have been considered.

The rating was done according to the procedure of DGNB with 10 percent as minimum reflecting the required performance by law and 100 percent (max.) for best practice (see figure 2).

Figure 2. Rating scale.



Additionally, the weighting of the indicators also differs for type I and type II as for example the thermal comfort is of greater significance for sports halls than for stadiums.

3_Results

3.1_Main Criteria

The results of the present study are in summary a set of 36 criteria as shown in table 2. As can be seen from the table, there are some significant differences to the certification schemes analysed (table 1). The indicators 'Light Pollution' (ENV 1.4) and 'Noise Prevention' (TEC 1.7) were added as these topics are of specific interest when assessing sports facilities.

Number	Criteria	Category
ENV 1.1	Life Cycle Impact Assessment	Environmental Quality
ENV 1.2	Local Environmental Impact	
ENV 1.3	Responsible Procurement	
ENV 1.4	Light Pollution	
ENV 2.1	Life Cycle Impact Assessment - Primary Energy	
ENV 2.2	Drinking Water Demand and Waste Water Volume	
ENV 2.3	Land Use	
ECO 1.1	Life Cycle Cost	Economic Quality
ECO 2.1	Flexibility and Adaptability	
ECO 2.2	Commercial Viability	
SOC 1.1	Thermal Comfort	Sociocultural and Functional Quality
SOC 1.2	Indoor Air Quality	
SOC 1.3	Acoustic Comfort	
SOC 1.4	Visual Comfort	
SOC 1.6	Quality of Outdoor Spaces	
SOC 1.7	Safety and Security	
SOC 2.1	Design for All	
TEC 1.2	Sound Insulation	Technical Characteristics
TEC 1.3	Building Envelope Quality	
TEC 1.4	Adaptability of Technical Systems	
TEC 1.5	Cleaning and Maintenance	
TEC 1.6	Deconstruction and Disassembly	
TEC 1.7	Noise Prevention	
TEC 3.1	Mobility Infrastructure	
PRO 1.1	Quality of Project Preparation	Process Quality
PRO 1.3	Design Concept	
PRO 1.4	Sustainability Aspects in Tender Phase	
PRO 1.5	Documentation for Facility Management	
PRO 1.6	Design and Urban Planning	
PRO 2.1	Environmental Impact of Construction	
PRO 2.2	Construction Quality Assurance	
PRO 2.3	Systematic Commissioning	
SITE 1.1	Local Environment	The Site
SITE 1.2	Public Image and Social Conditions	
SITE 1.3	Transport Access	
SITE 1.4	Access to Amenities	

Table 2. Set of Criteria for Sustainable Sports Facilities.

3.2_Subindicators for sports halls (type II)

Sports facilities require specific conditions and characteristics. In the following some subindicators for type II (sports halls) will be described more in detail illustrated by some examples.

3.2.1_Commercial Viability - ECO 2.2

The aim of the criterion 'Commercial Viability' is to assess whether a building has the potential to respond to medium and long-term user demand in the relevant market. Concerning sports halls in particular the sports development planning is an important tool. With sports facility planning the needs of the current sports situation of a municipality can be identified and therefore an important basis for the design, construction and operation of sustainable gyms established (Landessportbund Hessen e.V., 2012). Usually it includes an empirical inventory, the identification of the needs, the setting of targets and measures and the coordination with relevant stakeholders. A subindicator was added assessing the sports facility planning depending on the performed extend.

3.2.2_Safety and Security - SOC 1.7

A high sense of security makes a vital contribution to people's comfort. Therefore, the aim of the criterion is to assess measures taken to increase the sense of security and reduce dangers. For sports halls, besides safety in the event of fire, safe main paths, safety in case of unpredicted danger, the prevention of vandalism and the prevention of accidents when doing sports are important aspects. Therefore, two subindicators were added assessing the measures implemented to prevent vandalism (e.g. access concept or video-surveillance) and the security management in regard to the sports equipment (e.g. weekly visual inspection, monthly functional test and yearly general inspection).

3.2.3_Visual Comfort - SOC 1.4

The criterion 'Visual Comfort' assesses an adequate supply of daylight and artificial light in the interior sports hall. Therefore, the availability of daylight, the prevention of glare and the colour rendering is evaluated. For sports halls in particular subindicators are added to assess whether the lighting was planned in detail and includes special lighting for the spectators, measures to support inclusion were implemented (e.g. separately usable rooms for men and women).

3.2.4_Design for all - SOC 2.1

The aim is to make the complete built environment available to every person and make it possible for disabled people to participate fully in all aspects of life, also in doing sports. For evaluating the accessibility of the building an exclusion indicator was added, to check either if regional handicapped sports group were included and considered in the identification of the needs or if a concept for refitting for handicapped accessibility exists.

3.3_Case Study 'Sporthalle Zorneding'

The municipality of Zorneding decided early in the planning stage to implement their new triple sports hall 'as sustainable as possible' and to incorporate sustainability criteria of the Austrian and German Society for Sustainable Building (DGNB and ÖGNI) in the planning, construction and commissioning process. Since the beginning of the planning in 2011 the authors assisted the team of architects and specialist planners on sustainability issues. Therefore, the sports hall 'Am Sportpark' in Zorneding, finished in the end of 2014, represents an important contribution as a flagship project on sustainable building.

Some key aspects of the positive result are demonstrated in the following:

3.3.1_Planning Process

The later users were involved in the planning and realisation process from the beginning and meeting the users' requirements was a key goal. Within the scope of a sustainable planning process the following measures were implemented:

- visits of other sports halls
- preparation of a booking plan of the future sport hall for estimating the real capacity
- performance audit and life cycle costing
- analysis e.g. simulations regarding energy efficiency and building services such as local heating, heating system for the hall, illumination, ventilation and heat insulation.

3.3.2_Site

In the context of site selection specific site analyses have been carried out. After an intensive review process the present site besides the sports field area and the building yard, a fallow land directly beneath a former filled gravel pit, was chosen. As a result the project is a successful example of brownfield redevelopment.

3.3.3_Architecture

The sports hall was built as triple gym. The material and structural system is composed of a con-crete-timber construction that is covered with wooden slats from the outside. The roof of the changing rooms and further adjoining rooms is designed as green roof. The extensive translucent glazing of the hall provides a pleasant, natural brightness in the hall interior and calls attention by externally visible light accents in the evenings.

3.3.4_Accessibility

The use of the hall by athletes with physical disabilities, such as wheelchair athletes, was considered as part of the early planning. Due to a current lack of demand the requirements have not been fully implemented but only pre-equipped. So if necessary, the changing rooms and showers can be retrofitted with little effort at any time for handicapped accessibility. A lift to overcome the lowering of the sporting field already exists.
Keys for entering the changing rooms can be borrowed on-site by an electronic access system. The system (BUS) also controls electrical door contacts at all access points of the hall, the room temperatures, window opening and operating conditions of the building services and can be moni-tored from the municipality's town hall.

3.3.5_Energy Efficiency

Well insulated exterior components and a sophisticated ventilation concept form the basis for low energy consumption and low maintenance costs. The sports hall is heated by a gas absorption heat pump in the base load. The intensive investigations for an alternative realization of a district heating network identified no effective use. The heating surfaces are designed for a low-temperature control and increasing energy efficiency. The heat is transmitted by radiant ceiling panels in the hall and by underfloor heating in the adjoining rooms. For ventilation, an underground duct provides tempered fresh air, precooling in summer and preheating in winter, and assures an annual thermal comfort.

The already mentioned translucent glazing promotes daylighting and thereby reduces the need for artificial light. Simultaneously, the special glass (profile) prevents glare of athletes by its opaque characteristics.

3.3.6_Materials

Only PEFC (Programme for the Endorsement of Forest Certification) certified wood and wooden products were used. The performed life cycle analysis (LCA) indicates a minor impact of the building on the environment over the entire life cycle. Indoor air measurements demonstrated a good indoor air quality in all sports rooms.

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GREEN DISTRICT CASE STUDY IN REGGIO CALABRIA

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scenarios

Abstract

Research deals with energy consumption in urban and construction management and CO_2 emissions. Through the set-up of a specific methodology and its experimentation at an unprecedented City and District scales, the study compares energy consumption and CO_2 reduction of different scenarios of interventions based on the main pillars of the Green Conservation and Ecological Retrofitting. A Valuation Framework, helped by WebGis tools, supports present research, integrating:

- *unprecedentedly detailed 3D city-modelling;*
- *alternative scenarios (Sustainable versus Business as Usual) for city energy management;*
- *cost estimate of investments in alternative urban scenarios;*
- *valuation of energy management in an alternative scenarios;*
- *overtime economic and financial analysis, comparing alternative scenarios.*
- *Case Study. A real world design and social experimentations have been activated in Reggio Calabria (Italy) and Boston (USA). They constitute two Case Studies. The first one is going to be implemented in real world as an experimental <Sustainable Urban District Retrofitting> intervention in an urban neighbourhood whose features include:*
  - *6.400 residents;*
  - *490.000 m^2 of district total area;*
  - *125 urban blocks;*
  - *840 buildings;*
  - *800.000 m^2 of apartments;*
  - *2.500.000 m^3 of constructions.*

Key outcome of real world experimentation is the "ecological passivation" (i.e. insulation works by ecological materials with long life cycle for non-consumption of energy).

Global appraisal of experimentation provides valuation of the economic and ecological aspects quantifying the initial little higher costs of passivation and assessing the number of years needed to pay-back the additional cost of investment by the offset of a large saving in energy constant spending. It has been demonstrated, both theoretically and practically, that it is possible to reduce energy consumption up to 50%.

1_Introduction

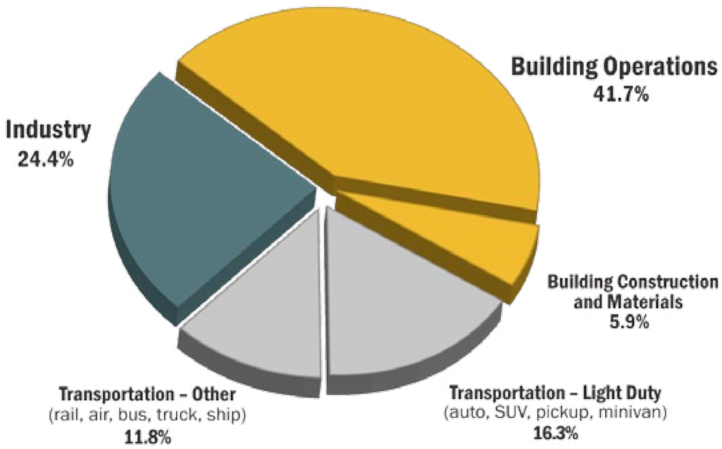
States and international organizations are aware of Earth environmental emergency, as well as of urban ecological and energy crisis. One causal factor among several is the disinvestment of existing old settlements and the migration of a high percentage of rural population to metropolis. A dramatic consequence is the wild urbanization of all available rural agricultural land surrounding original built areas in large cities and the increase of urban congestion which causes, among others effects, artificial mobility, private cars over-use, energy over-consumption, air over-pollution.

Communities and territories are addressed by leading organizations to treasure and re-use the consolidated old settlements, not to abandon them, and therefore to save the open and arable land surrounding cities and metropolis,

Attributions:
Massimo D.E. par. 2, 7.
Fragomeni C. par. 1, 3.
Malerba A. par. 4,
Musolino M. par. 5, 6.

by means of: revitalization of economy in historic towns and old villages; physical rehabilitation following their economic revamping. For more dense settlements already existing "Green Urban Conservation" actions are introduced and addressed such as: restoration and retrofitting interventions, characterized by both bio-ecological and cultural sustainability over the wide heritage; energy rehabilitation of buildings for dramatic consumption reduction; adoption of renewable energy sources; diffusion of zero mile decentralized energy production (with no transport) aiming to make local communities energy independent and, as much as possible, self-sufficient.
Analysts and policymakers, worldwide, have a growing strong interest in energy and environmental performance of the building stock and industry. The improvement of the energy performance of both new built and existing constructions is a physical and economic challenge for the future of urbanization. The ecological collapse hanging over Earth has stimulated to research the causes of the increasing and widespread environmental decay and to set-up shared strategies to over-come the criticalities burst-out in recent years.
The construction sector and, specifically, the energy management of existing buildings, according to international assessments, is responsible for over 40% of the total energy consumed on Earth. They are among others the major causes of: waste of resources; demand for fossil fuels and resources; CO_2 emissions; planet's pollution.

Figure 1. U.S. Energy consumption by sector. Source ©2011-2030 Inc. / Architecture 2030. Data Source U.S. Energy Information Administration (2012).



Pollutant emissions, consequent of combustion and one of the final outputs of the settlement process, are among the major causes of Global Warming (GW) on the planet according to the Intergovernmental Panel on Climate Change, IPCC (2007, 2013, 2014).
Sustainable cities are those cities that are more attentive to citizens' needs, in which energy and environmental issues and socio-economic interests are integrated in a harmonious way (co-evolution), forward-looking about the role of the private sector and focused on economic growth of the local market (Caragliu, Del Bo, Nijkamp, 2011).
In the last few years it has been developed and experimented few methods and tools to evaluate both energy and environmental building impacts also at city levels. For example http://www.urbmet.org/ by the MIT is a WebGis based tool, and the NYC energy usage map realized by Sustainable Engineering Lab (formerly Modi Research Group) from the Columbia University give evidence

of the total annual building energy consumption at the block and lot level. Estimation is made using mathematical model based on statistics, not on individual building data.

However, while the tools to evaluate buildings energy - environmental efficiency have increased, also due to the issue of European standards on energy consumption reduction, the sustainability evaluation made using analytics model has been less investigated (Massimo, 2009).

Research tries to overcome the lack of a shared and common methodology that allows an objective assessment of: sustainability at urban level and impacts of ecological investment in pollution mitigating.

2_Methodology

Research aims to set-up, at urban scale, a general methodology and appraisal framework to quantify energy saving and financial pay-back period of green different investments. A case study approach is adopted in this research in order to verify methodology effectiveness and its replicability in different contexts.

Research deals with the principle of New Sustainable Urbanism, specifically faces and confronts the emergency of the growing energy over consumption in human settlements, particularly in urban areas. It investigates the possible global solution to the inefficient thermal behaviour of modern buildings as well as to the excessive civil energy consumption, and consequent CO_2 emissions, one of the principal causes of the Global Warming.

It has been built-up a connection between urban regeneration - rehabilitation strategies and building energy efficiency by integrating several information and valuation elements within a GIS framework: 3D city modelling; design of actions for a Green City; cost estimate of actions for Green City investments; valuation of running energy yearly demanded; comparison with the status quo as well as further un-sustainable scenario; appraisal of operating costs in alternative scenarios; comparative ecological impact analysis of alternative scenarios; comparative economic analysis over time of alternative scenarios.

Research is divided into steps going from the climatic-energy behaviour assessment as well as enhancement of single buildings to the generalization of the interventions at urban and city scale.

Impacts of Green Building global actions at urban level should be:

1. **insulation** at urban level for structural and forever energy saving, i.e. thermal "passivation" of existing buildings and hydro, humidity and moisture regulation (perspiration) of constructions;
2. consequent sizeable **reduction** of energy consumption at urban level for both winter heating and (more important) devastating summer air-conditioning in the existing buildings; integrated with:
3. **energy production** (decentralized at zero mile) by means of solar photovoltaic and thermal panels at urban block level integrated into building pitched and flat roofs;
4. **reduction** of CO_2 emissions at urban level as a consequence of the lower and lower fossil material combusted;

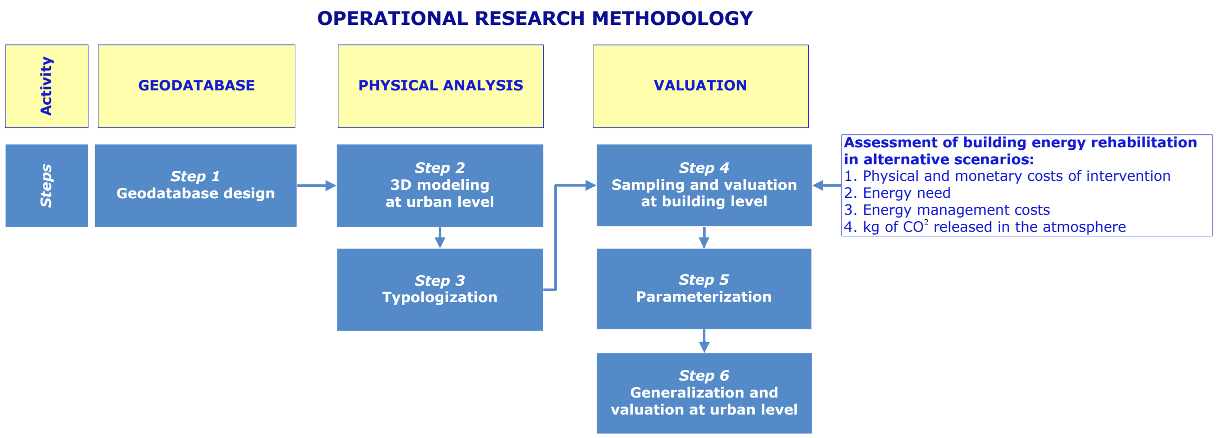
5. **curb** of total running cost in the building life cycle defined "thermal positive premium" to be assessed over-time in:
   - environmental terms (by summing up all the avoided pollutants);
   - energy terms (by summing-up the avoided kWh or Megawatt, i.e. not employed);
   - monetary terms by summing-up all savings;
   - financial terms, actualizing future money, using appropriate rates.

A system framework has been set-up for valuation of Green Urban Conservation Strategy, tested in the Case Study and articulated in some main activities such as:

- "Geodatabase" activity, i.e. application of Geodatabase to reality, and design of a geographic information system dedicated to get urban information;
- "Physical Analysis" activity, i.e. geometrical modeling at city scale and urban 3D information system: 3D; typologization;
- "Valuation" activity, i.e. behavioral and metabolism modeling and integrated energy - ecological - economic - financial analysis: sampling; parameterization; generalization.

Each activity produces outputs which intersection allows to achieve one of the research goals, i.e. to calculate the energy saving, the "passivation" or rehabilitation costs as well as the energy management costs at single prototype building level. After that it is possible to generalize the results at the uncommon and unprecedented valuation level of neighbourhood and entire urban areas. Urban strategy aims to redirect the unavoidable ordinary maintenance works toward building passivation with specific interventions involving external plaster and roof renovation with natural ventilation and insulation. All this is designed in an original way that allows the works to be done only in the exterior avoiding the resident to move leaving their houses. The above summarized implementation process of strategy integrated valuation is therefore articulated in the steps of the following operational methodology drew-up in the Flow Chart.

Figure 2. Logical Char. Methodology for sustainable retrofit generalization at district and urban level.



Methodology implementation at the urban level, allows to identify areas of potential or actual decay to which priority of intervention should be given since it makes possible to get the following information: historical documents; morphological-settlement and architectural quality; integrity and/or alteration of the original features with a particular linguistic value; level of buildings conservation; location, quantification and estimation of maintenance costs for alternative scenarios; energy demand and estimation of management costs; analytical knowledge of the boundaries of the property through the identification of land register subordinates useful to identify future recipients of the interventions. This information enable to estimate democratically the needed actions at the building, urban block, neighborhood or district levels, through a dialogue with the owners and occupants.

3_Case Study at district level

To test the methodology, research has developed a Case Study, designing "passivation" of whole neighborhood aimed to implement in real world a Green District located in Calabria, a South Italy Mediterranean region, a backward area for product, income, energy dependency.
Case Study is located in the town of Reggio Calabria, rebuilt at the beginning of 1900 as an interesting *Art Noveau - Liberty* new settlement. Reggio Calabria comes to be a high quality Urban City with an exemplary system of road grid, urban block pattern, squares, public buildings, private constructions, and an extraordinary waterfront: "the most beautiful mile of Italy". Nowadays this urban settlement is referred to as such an example by the International Movement: Congress of New Urbanism (CNU).

Figure 3. Case Study. Reggio Calabria, Italy. The Latin Quarter. Identification of the Case Study area. Source: author's working-out from a Bing Maps 3D view.

3.1_Alternative scenarios of intervention: Sustainable versus Business as Usual (BAU)

Research highlights the possibility to act for urban mandatory conservation, energy consumption and CO_2 emissions reduction by acting on the same kind of decay with alternative approaches (comparative scenarios technique): sustainable versus Business as Usual (BAU).

3.1.1_Sustainable Scenario

It is conservative and high energy efficient. Its design adopts, at building level, ecological techniques and bio materials with long life cycle (sometime perpetual) to reduce heat dispersion toward the outdoor as well as to cut fossil fuels consumption for heating and conditioning and consequently to lower down related CO_2 emissions. In the case of sustainable scenario materials are the following.

1. **Plaster renovation** of external wall coating for insulation makes use of "volcalite" (©HD System), i.e. mortar made of natural hydraulic lime (clinker - cement free) with special inert elements highly insulating, such as expanded perlite, vermiculite and pumice.
2. **Roof insulation** and **waterproofing** renovation adopts natural perspiring membranes with aerating, ventilating and insulating groove panels made of natural materials such as fluted cork (©lis).
3. **Windows replacement**: single glass windows are replaced with double ones with air space; aluminium windows are replaced by new ones made of highly insulating materials.

3.1.2_Business as Usual (BAU) scenario

Its design employs popular materials commonly used in ordinary construction yards or building site, i.e. *chantiers*, characterized by poor thermal behaviour and mediocre (almost inexistent) insulating characteristics that sometimes make worse and worse the energy dispersion compared to the *status quo ante*. These materials are on one side cheaper to buy and easier to install, but on the other side they do not help neither building efficiency nor city energy management because they do not have good thermal and insulating characteristics.

1. **Plaster renovation**, in BAU scenario, is made using mortars made only of sand and cement with a high level of transmittance, applied to vertical surfaces;
2. **Roof insulation** adopts epossidic membrane without neither insulating nor perspiring characteristics, in substitution to the old natural asphalt for roofs and balconies waterproofing;
3. **Windows replacement** highly emissive, not-ecological and inefficient metals (aluminium) for doors and windows.

4_Prototype Building. Example from real world

Methodology is based on real world experimentation on prototype buildings performing passivation yard or *chantier*. One has been carried out, doing a real "passivation" of the large Main Room of the Regional Administrative Judicial Court of Reggio Calabria, through roof "green" insulation and ventilation.
Based on the envelope thermal analysis carried out before, a Global Maintenance Program for Urban Block #128 has been designed. It consisted in: ecological insulation and ventilation of the pitched and flat roofs by adopting Italian natural cork; wall plaster renovation using natural hydraulic lime; windows replacement.
Thermal analysis highlighted that, in the energy balance of the wide hall, the wooden roof, with its 20 x 12 meters (240 m^2), is the area with the greatest thermal dispersion. The core of the Global Maintenance Program has been the design and the real sustainable intervention of energy rehabilitation through the roof insulation and natural ventilation by inserting on the planks covering a material with thermo-insulating and ventilating air-entraining agent such as: natural bio-ecological cork produced in Italy; a wooden frame with ventilation chamber; a screen for the summer heat; a layer of breathable sheath.

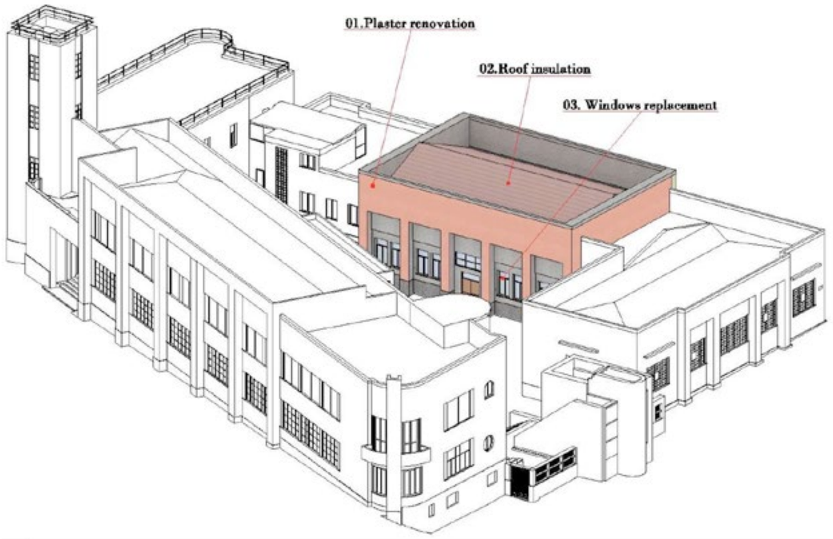


Figure 4. Case Study. Reggio Calabria. Italy. Prototype building. Court Room roof "green" insulation. Source: authors' working-out.

It followed a huge energy saving, and the yearly annual energy consumption is reduced by almost the 50%.
The first positive economic effect is a considerable reduction of the energy management costs.
By adopting an analysis period of 20 years, with a discount rate of 4%, for the important cost differential between "Business as Usual" scenario compared to "Sustainable" scenario, pay-back period results in 8 years.
Further innovation is the post-intervention monitoring through the use of temperature sensors (i-buttons). Today, the building is constantly monitored by temperature data loggers to control the effect of insulation and ventilation upon internal temperature constantly compared to external temperature. The data duly processed demonstrated the success of the intervention in terms of indoor comfort (temperature-moisture) achieved.

5_Real world Green District. Design and appraisal

New wider eco-urban approach as well as new technological strategic support (such as valuation GIS tools) have been deployed and employed in a real world design and social experimentation, constituting the Case Study, concerning the fostering-up of an "Ecological Green Urban District" in an already existing urban area.
The neighbourhood or district has been usefully mapped into a 3D valuation GIS giving the relevant extension of: 490.000 m^2 of district total area; 125 urban blocks; 840 buildings covering a built-up area of 208.000 m^2 with 2.500.000 m^3 of built volume; 800.000 m^2 of apartments; over 400.000 m^2 of fronts to be insulated; about 180.000 m^2 of roofs to be aerated-ventilated and insulated; a population of 6.400 residents, plus thousands of University Students living (because of this, the area is named "Latin Quarter") there as non-resident renting rooms and flats privately and unofficially during the academic year.
Urban Sustainability works for passivation real world Case Study especially insulation with natural materials have been designed and valuated in their environmental and energy impacts. In prototype experimentation buildings, natural insulation and ventilation reduce the needs and energy consumption

for winter heating as well as for more demanding summer air conditioning. Relevant is also the amount of avoided Kg of CO_2.

"Typologization" divides the built environment in typologies on the basis of architectural characteristics (considering both structural and architectural language). On the basis of the detailed analysis conducted and thanks to the in-situ testing and feedback, it has been created a specific thematic map that identifies the four different prevailing building typologies within the Case Study area: Eclectic of Reggio Calabria; *Art Noveau-Liberty*; Rationalist; Contemporary \ speculative.

For each typology, parameters of interventions, energy, saving costs, have been derived from correspondent experimental prototype buildings.

The use of GIS tools makes possible automatic assessment at neighbourhood or district or quarter level. By using cost and energy parameters calculated, it was possible to estimate for the entire Quarter:

- the total physical amount of works in the two alternative scenarios (pure usual maintenance just according to code, BAU, versus "passivation");
- the total monetary investment cost of works per each scenario and typology;
- the energy consumption per each scenario;
- the total annual running costs in each scenario;
- the pay-back period of additional cost for "passivation" (sustainability premium);
- Kg of CO_2 emitted into the environment for each scenario.

6_Green District. New evidences

Strategy implementation aims to redirect and change the ordinary maintenance works toward building envelope passivation with specific interventions consisting in: external plaster; roof renovation; and windows replacement. A generalization has been performed from architectural prototype to district level.

6.1_Green District. First assessment

6.1.1_Total monetary cost of works

1. Front passivation. Passivation of vertical surfaces (front; elevation) of 400 buildings (50% of total) is considered. It can be foreseen a cycle of only six or eight years for the completion of a program of 400.000 m^2 (1.000 m^2 per building) with an average of 82 m of perimeter and 12 m of height. Front passivation for 400.000 m^2 for a medium cost of 80 €/ m^2 determines a potential minimum investment of € 32.000.000 for the 50% of total neighbourhood (400.000 m^2 x 80 €/m^2 = 32.000.000 €).
2. Roof insulation. The thermal-insulation and ventilation of roofs for 180.000 m^2 with aerating natural cork has a cost of 60 €/m^2. Total investment amount of € 10.800.000 for the whole neighbourhood (180.000 m^2 x 60 €/ m^2 = 10.800.000 €).

Summing-up. It follows that the total cost of passivation for roof and the 50% of fronts neighbourhood is € 42.800.000 (i.e. for the whole district: € 85.600.000 in the sustainable scenario vs € 64.400.000 in the BAU scenario).

It is of paramount importance to keep in mind that a large and majority part of this amount must be spent in any case for mandatory unavoidable maintenance works in common way i.e. BAU. Then sustainability accounts only for a small part of expenses, exactly the differential for bio-ecological materials with almost perpetual life cycle.

This differential is shortly recovered by the owners of single housing with annual instalments constituted by the substantial saving on energy bill, above described and quantified.

6.1.2_Energy consumption

The existing total built volumes, assessed by means of the built GIS, are 2.500.000 m^3. By considering an average height per unit of 3 m, it is possible to give a first estimate of the built unit surface in the entire neighbourhood of about 830.000 m^2 to be managed on energy side.

Sample analyses performed on the different prototype buildings have shown, in a very conservative and prudential scenario, an average theoretical energy need per m^2 a year of 100 kWh\m^2 in the BAU scenario and of 60 kWh\m^2 in alternative sustainable scenario. By multiplying this parametric data for the total 830.000 m^2 of all buildings it can be obtained a first rough result of the total energy need for the entire neighbourhood of about 83.000.000 kWh per year for the BAU scenario vs 50.000.000 kWh per year for the sustainable scenario with a differential or saving of 33.000.000 kWh (-40 %).

6.1.3_Total annual running costs

In a very conservative scenario, considering the pure production cost of energy of 0,19 €\kWh, it can be obtained a total expenses of energy management of about € 12.450.000 per year for the BAU scenario.

Research, field work, yard observations, as well as specific experimentations performed on the sample prototypal buildings, assuming an intervention of sustainable energy rehabilitation, have highlighted an average reduction of 40% of the theoretical amount of energy need. Considering the average cost of 0,19 €/kWh it can be obtained a smaller total expense per year for energy management of about € 7.500.000.

The consequent monetary amount of year energy saving is of € 4.950.000. Considering a total saving of passivation equal to € 4.950.000 per year, the correspondent payback, at steady rate of 4%, can be assessed in about 5 years.

6.2_Results

All the results are summarized in the tables below.

		BAU	Sustainable	D	D
		x1000	x1000	x1000	%
Investment work cost. One shot	€	64.400	85.600	+21.200	+ 24
Energy needs. Year	kWh	83.000	50.000	- 33.000	- 40
Energy management costs. Year	€	12.450	7.500	- 4.950	- 40
CO_2 emission. Year	kg	16.000	9.500	- 6.500	- 40

Table 2. Green District. Data Summary. Passivation investment and energy costs.

Blocks	n	125
Buildings	n	840
Roof area	m^2	180.000
Facades \ elevation	m^2	400.000
Volume	m^3	2.500.000

Table 1. Green District. Data Summary. Built area and volume.

Table 3. Green District. Fast Pay Back Period in five years (i=4%), of € 21.200 differential.

Yrs	Energy Saving	Rate	Saving Actualiz	Saving Sub-total
n	*€ x1000*	*(1+i)-n i=4%*	*€ x1000*	*€ x1000*
1	4.950	0,961	4.759	4.759
2	4.950	0,924	4.576	9.335
3	4.950	0,888	4.400	13.735
4	4.950	0,851	4.216	17.952
5	**4.950**	**0,821**	**4.068**	**22.020**
6	4.950	0,790	3.911	25.932
7	4.950	0,759	3.761	29.694
8	4.950	0,730	3.616	33.310
9	4.950	0,702	3.477	36.787
10	4.950	0,675	3.343	40.131
.....	.....	.....	.....	....
20	4.950	0,456	2.258	**67.236**
Tot			**67.236**	

7_Conclusions

Research has set-up, tested an experimental approach – strategy - methodology, based upon a Case Study of urban regeneration. Particular attention was paid on the environmental and climate dimensions of the built environment.
Experimented research strategy allows to set-up a large scale plan to enforce Sustainability policy at urban level and to achieve the objectives of energy saving programs. The operational methodology allows to: precisely quantify and estimate the general urban plan for energy saving; reduce the necessary times of investigations; provide guidelines to firms, investors, realtors, households, Society and to local Governments on the possible results achievable by large urban scale interventions; derive keystone prototype data. In fact, in the specific research here presented the clustering of buildings per typologies has allowed, by surveying and studying carefully a limited number of paradigmatic prototype and sample buildings, to obtain reliable results in a reasonable time, to employ less activity, to reduce the costs for the analyses, estimate, assessment and design.
At the end, besides the most relevant outcomes above cited, research has achieved the possibility to: sort out parametric costs and energy consumption data per m^2; even in conservative scenario, develop subsequent cross-analysis thanks to the build-up of a geodatabase within a geographic information system; deepen the assessment for entire urban areas; include environmental and monetary effects of avoided CO_2 pollution, and considering them in assessment of "first cost" period of return. All the created data, collected information, performed analyses, are organized safely in a stable, querying, flexible and open geodatabase system.
Finally, intervention simulation in the Case Study area shows that with the building passivation strategy it is possible to achieve an energy saving of 40% equal to 33 million of kWh in the neighbourhood each year, by analyzing just winter heating, taking into mind and account that impact on expensive and demanding summer air-conditioning will produce even more and more benefits both monetary and ecological. The methodology has been tested in a real

world yard prototype. The post-yard permanent monitoring of temperature and humidity, performed with remote data loggers (i-button) has positively confirmed the ex-ante valuations. The positive results achieved give two empirical positive evidences:

- physical, in terms of energy saving thanks to sustainable bio-ecological materials employed;
- economic, with a short period of pay-back of the "initial cost monetary negative premium".

These empirical evidences encourage to follow the path of Sustainable Urban Conservation at large scale and to test the methodology in other prototype buildings and in different climate zones, detecting the local indigenous bio natural materials, at almost zero mile, to be adopted as ecological insulation for green building and district.

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VALENCIA CITY COUNCIL EDUCATIONAL CENTRES FOR CLIMATE CHANGE AND ENVIRONMENT

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Abstract

Valencia City Council its compromised with the climate change and protection of environment, which has been translated into specific energy efficiency policies to reduce CO_2 emissions, participation in city networks and action plans focused, but one of the main pillars of the Sustainable Energy Action Plan, is the promotion of public awareness, mainly focused on schools, providing interactive and information resources as well as open spaces for citizen participation in which developing the basis of environment protection, CO_2 emissions reduction, recycling, etc.

1_Education and public awareness initiatives on climate change of Valencia City Council

There are cities which assume the 75% of the population nowadays and the forecasts underline the growing trend of the population in cities. Under this premise, the Valencian government has adjust and adapt the city and its infrastructures to the fight against climate change, with particular emphasis in public awareness.

In this line, Valencia has proposed reducing by 20% the emissions of greenhouse gases in 2020, taking as reference emissions 2007. The city took this commitment in 2009 with the signature in Brussels joining the European Covenant of Mayors, ant it was increased last October to reduce by 40% the CO_2 emissions in 2020. To this end, the “Strategy against Climate Change” was launched, comprising the “Environmental Action Plan”, the “Climate change Environmental Plan” and the “Sustainable Energy Action Plan” as a guideline to be followed by all related departments of the City Hall.

As a result of these initiatives, Valencia has managed to reduce by 13% the CO_2 emissions into the atmosphere, as it emerges from the last recorded data, comparing between 2007 and 2012. This represents more than half of what the city proposed for 2020.

Among others, the main factors that have contributed to this drop in emissions of harmful gases have been the decline in traffic, along with the spectacular rise of cycling (Valencia has a public bike system with the high acceptance and use in Spain, according to the Observatory of Public Bicycle in Spain), and the gradual incorporation of buses using fuel with lower emissions of CO_2 (biodiesel buses, compressed natural gas buses and hybrid buses) or the purchase of electric vehicles for municipal fleets.

But the City Council not only works on climate change mitigation measures but also on adaptation measures, which the city undertook through its adhesion to the Covenant of Mayors for Climate Change Adaptation in October 2014.

That is why the Department of Renewable Energy and Climate Change of the City of Valencia, has started preparing the “Plan for Adaptation to Climate Change in the municipality of Valencia”, within recently has been completed the report “Risk Analysis and Vulnerability Climate Change”, which provides more precisely the possible consequences of climate change locally, and concludes that, in general, they are higher than those estimated for the whole Mediterranean area by the Intergovernmental Panel on Climate Change.

In summary, the analysis states that in the future, temperatures and extreme events such as droughts and heat waves, will rise, and Valencia would have a greater vulnerability address these changes.

Thus, to reduce the expected impact of this analysis, it has decided to follow a model of integration of new information and communications technology in the area of environment, mobility and energy; model aligned with the European Strategy Horizon 2020, and framed in the Smart City Strategy of Valencia, which will manage indicators to measure the city in real time to reach a resilient and smart city by 2017.

All these policies, city models and technological applications, are necessary to have a resilient city, but a city must not forget the importance on working continuously to raise public awareness, starting with school-age citizens. In this line, in the last "Sustainable Energy Action Plan" of Valencia, one of the strategic lines of intervention is the environmental education and public awareness, which is transformed into the following actions:

- Promote public awareness
- Raising awareness in schools
- Build sustainability.

Valencia City Council is investing resources so that citizens have the necessary information to enable them to collaborate in the reduction of greenhouse emissions in the city, and get a friendly and sustainable city for future generations. For this purpose, the municipality have created three specific centers: the Bio-Office, Naturia Center and the Valencian Observatory on Climate Change. These centers are equipped with the latest technologies and interactive activities, where visitors have the opportunity to learn what climate change is and what he can do to help mitigate emissions of greenhouse gases. At the same time, they have the opportunity to express their opinions about city projects and make suggestions. Each of these centers received over 10,000 visitors in the last two years.

Figure 1. Logo of the Smart City Strategy of Valencia.

1.1.1_Valencian Observatory on Climate Change

Manage by the Valencian Observatory on Climate Change Foundation, depending on the City Council, was created in 2.012 with the aim of raising awareness among school children. It is a center dedicated specifically to show the international scale environmental problems like climate change, and the awareness of how to fight against climate change, and contribute on sustainable development.

Figure 2. Observatory on Climate Change interactive screen.

Figure 3. Observatory on Climate Change exhibition halls.

The design of the exhibition center and the used of advanced technology (augmented reality, 3D, etc.) and audiovisual systems, makes it an interactive and dynamic space, which serves as a meeting point for all audiences for a fully interactive experience.

1.1.2_Naturia center

Besides, Valencia City Council promotes the environmental education through the "Naturia Center", the Local and European center for the promotion of Urban Environment and Sustainability. Naturia is seen as the first open learning center for all ages, where the public receive an important lesson on how to live in the urban environment respecting the green areas, promotiung activities in the bed of the Turia River, the largest urban garden in Europe (110 Ha).

Figure 4. Aerial view of Naturia facilities in the Turia urban park.

Turia River has historically been the umbilical cord that has linked the city of Valencia with its immediate natural environment: the orchard area around the city, the Albufera Natural Park, the sea and interior drylands. Naturia

represents the possibility of returning Turia River space its former role of aproaching Nature to the city, but with a renewed vision: the urban environment and sustainability.

Figure 5. Naturia facilities in the Turia urban park.

1.1.3_Bio-office

It is an information, training and environmental education space, created in 2.012 dedicated to urban environment that seeks to maintain an open and ongoing dialogue between citizens and the City Council in environmental issues. This centre is more focused on adults interested in contributing to the improvement of their city and their daily habits related to energy use, recycling, etc.
The Bio-Office has a library and documentation center on climate change and environment, to facilitate public consultation and civic education. This is the first municipal environmental space that launches Book crossing practice or free exchange of books in this line.
In addition, it receives advice and guidance on issues related to sustainability, climate change and environmental protection in our city, like: Learn sustainable food habits, Calculate the carbon footprint, Get tips for saving water and energy, or Join the "Green Homes" program, which consist in developing an energy audit to those citizens interested to know in more detail their energy expenditure over a year, with monthly meetings.

Figures 6, 7, 8. Some of the rooms of the Bio-office.

Also, citizens can leave their suggestions or perception on their city, which contribute to maintain the communication between city hall and citizens.

2_Impact

The potential audience that can benefit from public awareness to climate change and environmental protection, is as follows: Valencia has 259 pre-school and kindergarten centers, 165 primary schools, 117 secondary schools providing compulsory education and 66 centers for bachelor's degree. A total of 10,000 citizens over in the last two years have participate in the activities of these centers.

The initiatives presented, have an average age of five years, so it is early to draw conclusions about the impact of awareness-raising activities taking place, but it is important that the city continue to invest human and material resources in this area, as long term can make the difference between those cities that have opted for the air quality in their cities, compared to those who have not taken precautions.

3_Valencia urban laboratory for innovation

3.1_Introduction

Every day there are many entrepreneurs who after a hard work manage to develop an innovative urban project implementation and are threatening his idea to not being able to test and validate their intelligent solution in a real environment.

If the technology is available to all citizens, whose role as protagonist of the development of cities is indisputable, why do not provide the city with an urban laboratory?

To this end, the city of Valencia in its Strategy Smart City Plan, is positioned as urban laboratory to facilitate testing of innovative initiatives in real environments of the city, where researchers, entrepreneurs, companies or public institutions can swiftly test their initiatives on the street and have feedback from end users.

3.2_Methodology

To coordinate this work and to facilitate that pilot projects can be tested in the city, InnDEA Valencia Foundation, a public entity of the City Council for promoting urban innovation, acts as an interlocutor and facilitator. InnDEA Foundation puts the infrastructure of the city available to entrepreneurs and researchers, so they can test their solutions in a real environment and with end users before taking the product to market, thus attempting to position Valencia as a city laboratory for testing innovative solutions in a real environment. The aim is to encourage more collaborative, participatory and social aspects of innovation in the city and it is essential that the final focus is the welfare of citizens and the search for solutions to improve their daily lives.

Another goal is to attract developers and companies outside Valencia interested in trying their innovations in a real environment, so that Valencia is positioned as a reference lab city. Share knowledge and best practices with other cities and actively participate in R & D & i, is another way to design the

intelligent city. In addition, InnDEA arranges the necessary requirements of the Municipal Services to enable the deployment of the solution, and offers to the collaborating institution the possibility of giving maximum publicity to the results of the testing, on social media, city networks and specialized media.

Figure 9. Nightway testing.

3.3_Results

The first action in this line of work has been carried out with the Valencian companies TECMENT Constructiva SL Technology and Management (technology-based) and Ecolumen MATEC APPLIED-Q SL (manufacturer and Installation Company), under the project name NIGHTWAY. It has installed a system based on a new photoluminescent material in a stretch of 30 meters in the area bike path La Devesa-El Saler, parallel to the coastline. The objective of this project is to improve the safety of cyclists traveling on the CV-500 road. In the next picture you can see the installed material.
This solution has improved the visibility of the road by the spontaneous emission of light from this ecological solution, and it is infinitely cheaper than other solutions that are currently used for the same matter.
The City of Valencia, through InnDEA, continues the development of the initiative of Valencia City urban laboratory for innovation, which functions since December 2015, helping companies, SMEs and entrepreneurs to develop their business ideas and improve the lives of citizens.

Photo: Shutterstock.

3.4_Other Study Cases

The objective of Valencia's participation in Spanish and European projects is for it to be a testing ground for the use and experimentation of the most innovative technology so as to consolidate it as an R+D+i point of reference in its urban application. Our city therefore plays an active role in the transfer of knowledge and the encouraging of innovation in both Spain and elsewhere. Projects such us **Light2CAT** (in the Climate Change field), **Smile** (in the mobility field) or **Transition Cities** (in the framework of Climate KIC), allow us to implement and prove new technology in the city of Valencia in order to test its functionality in a real scene.

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Abstract

This paper appraises the development of Hammarby Sjöstad, an eco-district located in the south of Stockholm. As a refusal of the previous unsustainable development, Hammarby Sjöstad is now well known for being built to the highest environmental standards. Since the 1990s, the area has been re-developed into a sustainable and innovative district, with mixed-use space and a low environmental impact. The main goal was to create a residential neighbourhood based on sustainable resource usage, simultaneously minimising energy consumption and waste production, while maximising resource saving and recycling. Hammarby therefore promotes efficient environmental management, with low-carbon development, renewable energy and well-integrated public transportation. It also strongly supports climate change reduction and a sustainable energy future by promoting energy efficiency and renewable energy. The building process has adopted an innovative sustainability technology, maximizing light and enhancing the views of water and green spaces. Likewise, the city has given great emphasis to sustainable and long-lasting materials such as wood, glass, steel and stone, showing the application of the modern architectural program that Hammarby promotes. The case study also reveals the powerful role of strong public sector leadership in ensuring high quality development. In fact, the project was based and delivered through a process of state-led consensus integration between all parties and at all levels. A major result of this successful integrated planning approach is the Hammarby Model, which deals with energy, fresh water and waste.

FROM POST-INDUSTRIAL WASTELAND TO ECO SUCCESS: THE INNOVATIVE RENEWAL OF HAMMARBY SJÖSTAD

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1_Introduction

Hammarby Sjöstad is an eco-district located in the south of Stockholm and developed around Hammarby Sjö Lake. In the 1990s it was a large industrial harbour with a negative reputation as a polluted and unsafe area. Since then, the area has been re-developed from a disused industrial brownfield into a sustainable and innovative district, with mixed-use space and a low environmental impact. Today, it is one of Stockholm's nicest residential districts and internationally it is held to be one of the most successful urban renewal districts; in 2010 the project helped Stockholm win the European Green Capital award (Notaras 2010) and an average of twelve international study visits take place every week to the GlashusEtt information centre in Hammarby Sjöstad (Rutherford 2013: 1).

This paper will first outline the project's conception, design and implementation and then explain why it is considered so successful, including its use of sustainable and long-lasting materials. Finally, it will focus on a number of factors that characterise the project, such as the interrelationship of its solutions, which could provide useful lessons for other similar projects in the future, including recent data on energy performance. For its evaluation of the quality and performance of the sustainability improvements the paper will draw on and discuss data that is widely available, also in the light of critical studies (Vestbro 2005, Adams et al. 2010, Pandis Iveroth & Brandt 2011, Rutherford 2013, Jernberg et al. 2015).

2_Strategic master plan, design and implementation

A strategic master plan for Hammarby was elaborated in 1994 by Jan Inge-Hagström, as part of Stockholm's proposal for the Olympic games in 2004. Later, Stockholm lost the Olympic opportunity, but the Stockholm City Planning Bureau nevertheless decided to develop the Hammarby site as a mixed-use urban area with a major focus on energy efficiency and sustainable development. Initially conceived in the 1990s, the first elements were completed in 2000. The project began with the delineation of the strategic master plan, divided into twelve sub-districts, and has been implemented as a series of development phases (fifteen in total). The implementation and control of the project has been helped by the City owning and acquiring most of the land in the area. A parallel sketch process was adopted for the preparation of a detailed plan for each sub-district. In order to test the master plan and prepare more detailed proposals for the sub-districts, the City involved many architects and planners. The City of Stockholm then evaluated the sketches and chose the best features to arrive at an agreed detailed master plan (CABE 2011).

As mentioned, the project has fifteen phases and a rapid build out process (approximately 600-700 units per year). Phasing has been efficiently managed so that the development is continuous and there are no large and obvious gaps in the middle of the urban form. Apart from the flats on the north shore, Hammarby's development has started from the core (Sickla Udde) and spread outwards. The implementation of the project has been achieved in a number of different ways, such as applying the strategic master plan for the entire neighbourhood, in order to guarantee the overall character of the plan to be implemented into practice, and detailed design codes for specific sub-neighbourhoods, encouraging an engagement process with the developers.

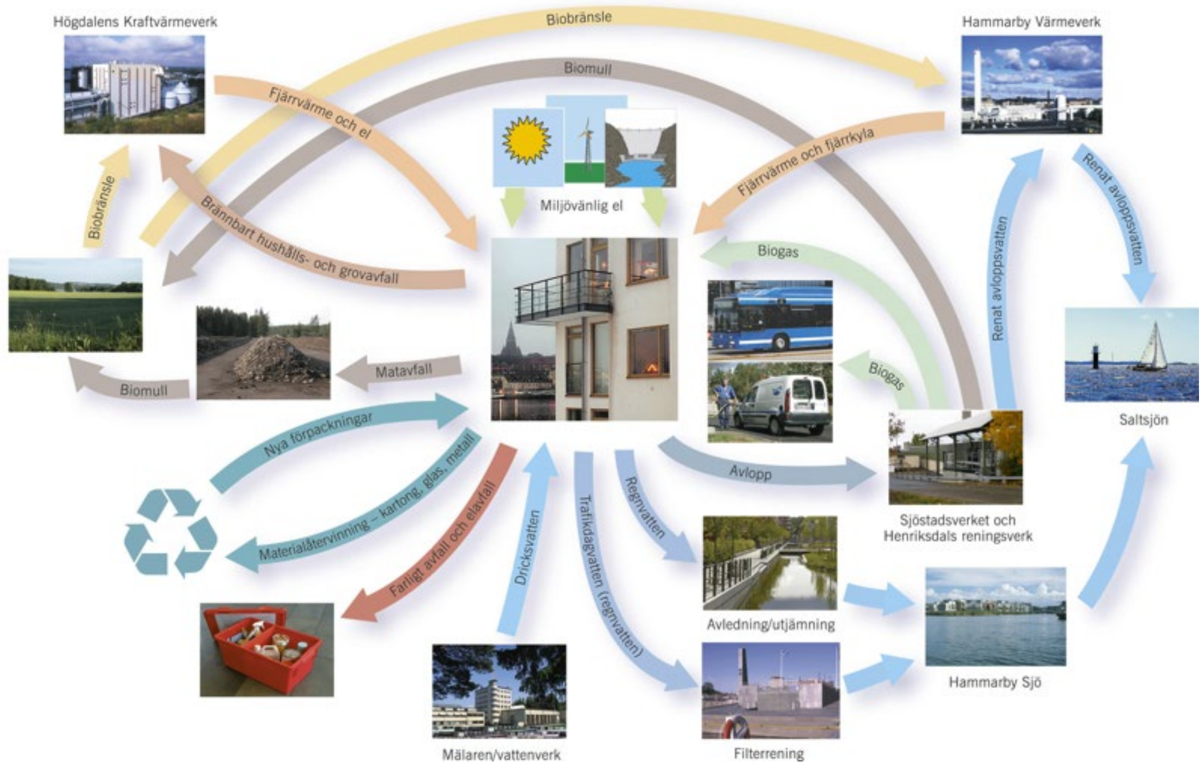

Figure 1. The Hammarby Model (source: Lena Wettrén, Bumling AB).

The building process has been strictly regulated and the codes which emerged from the detailed plans have been widely supported. However, both the master plan and the design codes have been "critical in translating the strategic vision to a local scale" (Adams et al. 2010: 116). Therefore, a two-stage process of detailed plans and quality programmes was adopted by the City Council. In particular, the detailed plans, made for the smaller details of the project, were based upon consultation between the City Council, the developers and the architects. After applying the detailed plans and guaranteeing the outcome of the building designs, quality programmes were also applied. These programmes, similar to the design codes, show a detailed specification of how each building must appear (Adams et al. 2010: 116).
The innovative parallel sketches process has been carried out to design the sub-neighbourhoods and a coherent design theme applied both to public buildings (e.g. the church) and to private development. As established by the master plan, the aim is to ensure both diversity and unity throughout the neighbourhood. Moreover, the project management has been helped by the collaboration between the various developers, the highly skilled team within the City of Stockholm, the robust environmental sustainability aspiration and land use policy. One of the most "striking features is the similarity between the master plan on paper, the aspirations it embodies and the physical environment as it has been developed" (CABE 2011) to ensure a neighbourhood with mixed-use space.

3_Strong local authority leadership and high stakeholder engagement

Since the beginning of the project, Hammarby Sjöstad has incorporated integrated urban planning into its design and implementation (Loftus 2011: 3) and the Hammarby design and decision model is well known for the strong local authority leadership during every stage of the master plan. Indeed, the Hammarby Sjöstad case study shows the powerful role of public sector leadership in ensuring high quality development, since the project was based and delivered through a process of state-led consensus integration between all parties and at all levels. The City Planning Bureau has collaborated with private sector architects, planners and urban designers, while the Stockholm City Council has had a leading role in engaging a large number of private and public sector actors, including 41 developers and 29 architectural practices. This process has led to a rapid and integrated development of the area with a robust local economy and high property values.
Moreover, Hammarby shows a high level of stakeholder engagement (e.g. private developers, architects, public sector stakeholders and residents) and numerous meetings have been organised throughout the project. The planning process has been successful and well integrated, with all of the different actors closely engaged since the beginning. Therefore, there has been great emphasis on the importance of collaboration between the various actors, each having responsibility for different segments of the project. This collaboration has led to 'new' ways of working or doing (Rutherford 2013: 13), involving partnerships and collaborations between different (public and

private) stakeholders. In particular, the City of Stockholm acted as land developer, promoting physical and social infrastructure (e.g. the tram extension), whereas the developers delivered apartments and commercial spaces, fulfilling the requirements of the specific design codes. The water, waste and energy actors (companies) worked together to produce the Hammarby Model (see figure 1) (Energy Cities 2008), aiming to put in place or to sustain existing pragmatic solutions for interlinking their respective infrastructures and flows (Rutherford 2013: 13).

Public interest has been supported by the Swedish democratic and transparent decision-making process and extensive forms of public participation and consultation were undertaken throughout the whole planning process. Further support was given by the nearby neighbourhoods, because the development of waterside paths and bike tracks along both sides of Hammarby Sjö potentially benefits residents in Södermalm. Paradoxically, public engagement and further modification and refinement of the design codes has become much harder now that the majority of the development is complete (Adams et al. 2010: 116).

4_From post-industrial wasteland to eco-success

4.1_Industrial wasteland

In the 1800s, the neighbourhood was a popular excursion destination for the inhabitants of southern Stockholm. The area was partially destroyed when the Hammarbyleden highway was built, and the seabed filled in with excavated soil, rocks and refuse as part of the planned port area (Fränne 2007: 6). A canal was built in the early 20th century to connect Hammarby Sjö Lake to the Baltic Sea, facilitating industrial development in the area. Rail lines were also built to enhance heavy industry such as the General Motors automotive factory and the Luma cooperative light bulb factory (Vestbro 2005). Over the years, light industry also located in this area, “activities of a type for which the City always has great difficulty planning” (Dastur 2005: 60). So after the early 1900s the site was mostly occupied by low value industrial buildings, storage depots, scrap yards and car breakers, and the constant threats of demolition show that the buildings in the area were of a temporary nature. In fact, no single company or industry established itself in the area and a “shantytown began to grow up, and the area eventually became a small-scale industrial area” (Fränne 2007: 7).

In the development of the area only one building of cultural value has been identified and preserved: the early modernist Luma bulb factory, today used as a conference centre (Vestbro 2007: 9).

By the 1990s Hammarby Sjöstad was widely regarded as an unhealthy and dangerous area, a haven for illegal activities and the consensual opinion was “it couldn’t be worse” (Adams et al. 2010: 116). Since the area was previously an industrial area, there were no pre-existing suitable public spaces, and because of its unsustainable and hazardous land and environment, as well as unregulated growth, the place had become undesirable for anyone to live in. Therefore, there was a general positive greeting for the redevelopment of Hammarby.

4.2_Modification of the urban structure

In the 1990s redevelopment proposals and plans were drafted. The removal of the various informal and illegal enterprises was possible because the City of Stockholm owned and acquired most of the land. While government officials "raised the threat of expropriation, they ended up compensating many business owners at rates far above market value to avoid lengthy appeals" (Gordan & Sigrist 2013). The decision to remove industry from the area was driven by a rising demand for a sustainable and ecological development of the neighbourhood. Indeed, Hammarby was one of the main locations for the government's 'build the city inwards' strategy (Poldermans 2005: 11) and a response to the suburban housing construction process during the 1960s and 1970s, commonly known as the 'million homes program' (Gordan & Sigrist 2013).

As a refusal of the previous unsustainable development, the main goal of Hammarby Sjöstad was to create a residential neighbourhood built to the highest environmental standards, thus a neighbourhood based on sustainable resource usage, where energy consumption and waste production are minimised, and resource saving and recycling are simultaneously maximised. As Hammarby is built on former industrial land, extensive decontamination was another essential and expensive main requirement.

4.3_Eco success

Today, Hammarby is a modern, semi-open, block-based neighbourhood. The inner street dimensions, block sizes, building height, density mix are integrated with the waterfront views and the green parks. Even though located outside the inner city, the design of the buildings is urban and follows the Stockholm City standards of street width (18m), block sizes (70x100m), density and land use (Gaffney et al. 2007: 50). The scale of development varies from four to five storey buildings along the Sickla Canal to six to eight storey buildings along the main corridors (CABE 2011). Some specific construction features of the Hammarby project are especially worth pointing out: along both sides of the Hammarby Seaway (Hammarbyleden) the buildings facing the water are tall and built in a classic inner city style, integrated with the large-scale quay facilities and open water areas; along the avenue (Sickla Kaj), large-scale, multi-functional buildings have been built, together with small-scale backstreet and courtyard houses between the dock and the new park walkway (Sjöstadsparterren); the setting along the canals (Sickla Udde and Sickla Kanal) is more intimate and small-scale, and buildings gradually develop towards the natural shorelines and beaches; Hammarby Gård has dense, urban milieus around a park area and a pool; Lugnet, on the shores of Hammarby Sjö, has a waterfront terrace (Lugnets Terrass) and a special building in the form of a latticed cube, double the height of those that surround it; Henriksdalshamnen harbour, among the last of the planned areas in Hammarby Sjöstad, has a large numbers of quays to create a harbour with space for restaurants and small boats. The majority of the apartments are privately owned or for rent and the percentage of those available for social housing is slightly lower than the Swedish national average of 20%.

The building process has adopted both the traditional city structure of Stockholm and an innovative sustainability technology, maximizing light and enhancing the views of water and green spaces (CABE 2011). Moreover, the City has placed great emphasis on the use of durable and sustainable materials such as glass, wood, steel and stone, showing the application of the modern architectural program that Hammarby promotes. The buildings have limited building depths, large balconies and terraces (which to look out onto the streets, waterfront walkways and open spaces), big windows, flat roofs and light colours on water-facing façades. Many of the apartments have a semi-open block form, thus providing open access to the courtyards of the residential blocks (CABE 2011).

The main backbone of the district is the 37.5m wide boulevard and transport corridor, which connects key transport nodes and public focal points, creating a centre for activity and commerce (e.g. shops, cafés, restaurants, supermarkets). Additional opportunities for commercial uses, are also provided through the two-storey pavilions along the Sickla Canal (CABE 2011).

4.4_Infrastructure integration and public spaces

Hammarby is very well integrated with the nearby neighbourhoods. The expansion of Hammarby coincides with the development of the area's municipal and commercial services, and with the increased investment in public transport. Much of the public infrastructure was put in place early on, such as the Hammarby Allé and its tramway, which links with Stockholm's T-Bana and ensures the development is well connected to the rest of the city, in direct contrast to Hammarby's previous status as a "somewhat ill-connected backwater" (Adams et al. 2010: 62). The public investment in land decontamination and transport infrastructure generated consequent private commitment. Indeed, "costs were recovered from sales of development parcels, so the municipality achieved a financial return as well as delivering an attractive new part of the city" (Adams & Tiesdell. 2013: 241).

Today, a network of various green spaces, squares and walkways runs through the district, providing public space for outdoor activities. All public spaces are owned and managed by the City of Stockholm. The aim for the development is to provide 25 square meters of public green space per apartment unit, for a total of 300,000 square meters in the district. The development has also the goal to provide 15 square meters of private courtyard space per apartment unit (Foletta 2011: 35). Attractive forms of public transport are also offered, such as the light rail link, boat traffic and access to a carpool (Fränne 2007: 9), highlighting the successful integration with the surrounding areas.

"I think it has been very successful, especially along the main road. There are lots of shops and restaurants and it is a location for good urban life and good public life. I also think there is a good mixture between the public parts (i.e. the parks) and the more private aspects (i.e. the courtyards)." Louise Heimler, Stockholm City Planning Bureau, cited in Adams et al. (2010: 118).

5_Achievements and lessons to be learned

Since the very beginning of the project, Hammarby Sjöstad has tried to achieve very ambitious environmental goals. This can be seen though the holistic Hammarby Model, an innovative closed loop system which allows waste, water and energy to integrate into each other. This approach also tries to better integrate the transportation system and technologies for water and energy into the existing urban infrastructure. In 2015, approximately 80% of the total energy use in Hammarby Sjöstad was renewable.

Even though the project is not yet finished, it has been the object of scrutiny and evaluation, as for example in Jernberg et al.'s study (2015). According to them (Jernberg et al. 2015: 73-74) the following overall goals have been achieved: all contaminated soils have been sanitized (soil remediation goal); 100% of all development land has been adapted to the district (land use goal); most of the commuters walk, cycle or use public transport (transport goal); the goal to purify water is almost achieved and 90% of the local waste collection traffic has been eliminated (water and waste goal); the energy goal is not yet fully achieved, but the average of 118kWh/m² energy consumption is still better than 150kWh/m² as a benchmark for construction at the time (energy goal) and the overall consumption is still lower than the average in Stockholm. In particular, the district's integrated system is alimented with approximately 50% of energy produced from renewable sources, including waste, and most of the building materials used in the construction, such as wood, glass, steel and stone, are either fully recyclable or could be recycled. The comprehensive planning of land use, transportation, and the eco-cycle has made it possible for every building to achieve a high level of environmental performance. So that, even though the energy consumption of buildings has still not reached the original goal, the project meets high environmental standards in comparison with similar international developments.

It is important to remember that one of the overarching aims of the project was to create an environmentally-friendly behaviour among the residents also through the design of the development's infrastructure. Surveys from 2007 declare that 79% of the all commuters walk, cycle, or use public transport. For Hammarby, it is often cited that 75% of pro-environmental behaviour comes from the design. The remaining 25% is achieved through raising awareness and educational projects targeted at all the key stakeholders. Individuals are also financially incentivized to reduce their environmental impact by being billed for their utilities in proportion to their usage (Jernberg et al. 2015: 13). Moreover, while the initiation of an ambitious Environmental Programme for the project appears to have benefited from the presence of a left-green majority in Stockholm of the mid 1990s, the fact that it was not abandoned by the subsequent right-wing majority (1998-2002) shows that it developed bipartisan support or could be aligned to quite different political goals and frameworks (Rutherford 2013: 14). For Jernberg et al (2015: 108) the major lessons to learn from the experience of the Hammarby Sjöstad's project include the following: that sustainable urban development requires a holistic approach; the importance of prioritizing the densifying of areas that are adjacent to the city, even if these are brownfields; that various departments from the government, the private sector, and academia must all be deeply involved in the planning process. To these we can add some other factors that typify the Hammarby Project, such as its emphasis on strong leadership alongside high stakeholder involvement, and on the interrelationship of solutions, as well as its focus not just on low carbon emissions but also on green areas to enhance biodiversity and also the residents' sense of wellbeing.

These factors can sometimes prove difficult to reconcile. Poldermans (2005: 24-5, 28) observes that while the large size of many windows facing the lake, providing nice views on the natural surroundings, is often appreciated and desired by the inhabitants, large windows do not fit into the strategy to reduce energy use in an environmentally sustainable housing project. Indeed, they can cause unnecessary heat loss in winter and in summer temperatures can reach high levels because of poor air circulation in some of the buildings. This reservation is in line with the comment by Rutherford (2013), following Pandis Iveroth & Brandt (2011), who notes that some of the strengths of the Hammarby project's visions are also its weaknesses. For example, "As a result of the holistic view, system based technical solutions were prioritized, but at the same time system technologies were not easy to join up with new environmental technology; such as solar cells, sun panels, fuel cells and other new technology" (2013: 12).

To conclude, there is no doubt that Hammarby Sjöstad serves as an important international showcase of the City of Stockholm's successful implementation of its eco goals. Moreover, it would also seem that the City is making good use of the lessons learned at Hammarby in its current development of the Norra Djurgårdsstaden (Royal Seaport) project to the north east of the city centre.

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THE RISE OF HUMAN FACTOR IN THE CHANGE OF ENERGY SYSTEMS: THE CASE OF 20 SUSTAINABLE DISTRICTS IN EUROPE

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Abstract

Although there is a broad agreement about the need for energy transition, the most effective way to achieve this remains unclear. Many of the attempts made so far, that have not been able to get the expected results, are based on a vision of change in which both the social and the individual dimensions are relegated to a function of "acceptance" of decisions that tends to come from the outside. These attempts risk to consider the human factor as a mere receptor, not an agent of change. In this framework the paper deals with some of the findings of the FP7 - MILESECURE-2050 project, and in particular the ones obtained from the analysis of a set of 20 sustainable districts. These case studies can be considered as "anticipatory experiences" of Energy transition, i.e. local experiences that contain some of the fundamental characteristics (thus, anticipating them) of a more complete transition to environmentally sustainable way of producing, consuming and managing energy. Introducing the holistic approach of "Human Energy", the paper shows how in these districts the emergence of a low carbon society is accompanied by the rising of the human factor, from a peripheral role (which occurs only downstream in the process of change), to a lead role in the change of energy systems (upstream in the process of change).

1_Introduction: Europan Sustainable Districts anticipates a low carbon society

This paper is based on some findings of the MILESECURE-2050 project. The project carried out a Europe-wide study into communities that anticipate at the local level some basic features of a future low-carbon society, i.e. Anticipatory Experiences - AEs. This "anticipatory" approach was developed in order to face the challenge of studying possible future dynamics focusing on concrete factual elements and not on mere hypothesis. The research team analyzed over 90 projects in 19 European countries which were selected from a long list of over 1,500 potential candidates. Some of the experiences analysed attempted to change a single aspect of their communities such as better sustainable transport, energy efficient housing, or the generation of property-level renewable energy. Others wanted to produce a holistic sustainable community that incorporated a fully functional and independent low-energy network. In synthesis, all AEs developed, or are actively developing, sustainable ways of producing, consuming and transporting energy. The AEs were found to be operating at different local scales ranging from neighbourhoods and towns to major cities. Their anticipatory character may be assimilated to their ability, at the present time, to take decisions and develop practical solutions to resolve issues that all the societies will have to confront in the near future, first of all those of climate change and the depletion of "carbon" energy resources. In this sense, AEscan be considered as already existing pieces of a future low-carbon society.
Among the AEs, 20 sustainable districts were studied. As shown in the following table it was found that in these districts a large set of actions related to different energy sectors were carried out.

Table 1. List of sustainable districts studied among Anticipatory Experiences.

N.	Sustainable District	Country	Start year	Renewables	Transports	Housing
1	Eko Viikki (Helsinki)	Finland	1999	X		X
2	Vauban (Freiburg)	Germany	1996	X	X	X
3	Eva Lanxmeer (Culemborg)	The Netherlands	1994	X	X	X
4	Augustenborg (Malmo)	Sweden	1998	X	X	X
5	Western Harbour (Malmo)	Sweden	2007	X	X	X
6	BedZed (London)	United Kingdom	1998	X	X	X
7	Hammarby Sjostad (Stockholm)	Sweden	1994	X	X	X
8	Kronsberg (Hannover)	Germany	1990	X	X	X
9	One Planet Sutton	United Kingdom	2009		X	X
10	Zac De Bonne (Grenoble)	France	2001	X	X	X
11	Rennaissance/Concerto – Lyon	France	2003	X		X
12	Quartiere Cristo	Italy	2007	X		X
13	Noorderplassen-West (Almere)	The Netherlands	2007	X		X
14	Zac Pajol (Paris)	France	2007	X		X
15	Ile de Nantes (Nantes)	France	2006	X	X	X
16	Lehen Sustainable District (Salzburg)	Austria	2007	X		X
17	Brussels Sustainable Neighbourhoods	Belgium	1993	X	X	X
18	Bahnstadt (Heidelberg)	Germany	2001	X	X	X
19	Superblocks (Vitoria Gasteiz)	Spain	2009		X	
20	Eco quartier des Brichères (Auxerre)	France	2003		X	X

In this paper we will summarize the results of the study of Anticipatory Experiences focusing on and providing examples from the 20 European sustainable districts that "anticipate" the low carbon society. To do that we will: discuss the problem of human factor in the context of energy transition (§2); present the holistic approach of "Human Energy (§3); highlight the evidence that came from the analysis of "anticipatory" sustainable districts (§ 4, 5 and 6); draw short conclusions on the rise of human factor in sustainable districts in transition (§ 7).

2_The problem of human factor in energy transition

2.1_A paradigm shift

Environmental and energy perspectives – and their implications on the political, economic and social spheres – have been, for at least 20 years (since the 1992 UNCED in Rio de Janeiro) central to the international agenda of the big issues facing the world.

This has resulted in a gradual change of the paradigm underlying the management of the global energy system. The "old" paradigm that oriented energy policies at different levels (production, distribution and consumption), was based on the unlimited (or at least very abundant) availability of energy resources; on the irrelevance (or minor relevance) of the impact on the environment caused by the exploitation of energy resources; and on the idea of decreasing costs of energy resources.

Later, what gradually emerged, mainly among the scientific community, the policy makers and the CSOs, was a new paradigm produced by the profound changes brought on by the emergence of new threats and challenges, such as the scarcity of non-renewable energy resources; the low environmental sustainability of the energy system; the increase in energy costs (especially for traditional sources). This paradigm shift also affected the European countries.

If it true that this paradigm shift is just one of the issues related to energy transition (fuel dependency, costs, risks and resiliency, geo-political relations, integration of EU energy system, etc.), it is also true that the change of paradigm described above is a issue highly connected to all the others. In fact, in order to face the challenges of climate change and energy security, Europe, now more than ever, is facing the need to re-discuss and renew its ways of producing and consuming energy. Reduced emissions, increased use of renewable energy and energy saving, are in fact some of the key objectives that Europe has set in its strategy for 2020 and beyond.

2.2_An unclear path

Although there is a broad agreement about the need to carry out this change, it remains unclear what is today the most effective way to achieve the transition toward a low-carbon society.

The attempts made so far, that have not been able to get the expected results, can be traced to three main approaches (or combinations thereof):

- those based on the penetration into society of new greener and efficient technologies (technological drive);
- those based on the introduction of new rules or restrictions that citizens should accept (normative drive);
- those in which new attitudes toward energy consumption (and savings) must be interiorized by the population (ethical drive or lifestyle drive).

If it is true that each of these approaches is needed to realize energy transition, all three are based on a vision of change in which both the social and the individual dimensions are relegated to a function of “acceptance” of decisions that come mostly from the outside. It is true that these visions of the energy transition recognize the importance of social and anthropological feedback, but they tend to consider the human factor as a mere receptor, not an agent of change. What actually is lacking, is the perspective of human agency, as a constitutive element of the transformation of the energy systems.

3_The Human Energy Approach

With the aim of addressing and overcoming the problem presented above, MILESECURE 2050 adopted an approach to make explicit and visible the latent role that the human factor exerts in energy systems in transition. Studying the AEs it is clear that, for the analysis of energy systems in transition, it is crucial to adopt a broader concept of energy that does not just include technological aspects but also social and personal dynamics. That is why during the project a new approach was developed, that is the Human Energy Approach, an holistic and all inclusive understanding of energy, articulated in three dimensions that show different ways in which the human factor lies behind the energy system:

a. Social energy, as the human capacity to bring together different forms of social activism that coordinate, and orient different social actors toward common goals and to overcome conflicts and oppositions that may represent a waste of energy;

b. Endosomatic energy, as the human capacity of effecting profound changes at the personal level in one's daily actions and convictions, in view of using the body in synergy with the energy system as a whole;

c. Extrasomatic energy, as the human capacity to activate and use the natural resources through the adoption of all kinds of equipment, technology or machinery (using all energy sources, whether carbon or low carbon).

This multidimensional approach was applied to frame the role of human factor in the "Anticipatory Sustainable Districts" development and management. In this way three social functions were identified, corresponding to the three dimensions of human energy. Those functions are listed in the following paragraph, providing on example from the district cases for each function.

4_Social energy and the cybernetic function

The social dimension of human energy can be interpreted as an adjustment of human and social relations that emerge in the context of the energy transition as a tendency of self-regulation. Such an adjustment – fulfilling what was called the "cybernetic function" – allows the governance of the energy transition. Tensions and conflicts that arise in the energy systems in transition are managed through a series of continuous, coordinated and simultaneous actions, as stated below:

- the active participation of citizens in decision making;
- the widespread practice of negotiation for the resolution of conflicts and enhance dialoguebetween different social actors in the area;
- the ability to maintain a continuous and multilateral communication on multiple levels (from informal to institutional communication);
- the creation of an institutional space for the energy transition, by including in the transition the traditional institutions, but also by actions such as the creation of new institutions or the transmission of the collected experiences to others.

4.1_An example of cybernetic function: Eva Lanxmeer (The Netherland)

Eva-Lanxmeer is a social-ecological district that has been built on a former farmland surrounding a protected drinking water extraction area. Located near the Culemborg railway station, Lanxmeer consists of 250 dwellings, 40.000 m^2 of offices and business units, an urban ecological farm (assuring biological food and contact with nature), an information centre, wellness centre, congress centre, bars, restaurants and a hotel. Lanxmeer integrates different urban functions providing good equilibrium between social, economic, cultural, educational, recreational and sustainable interests. Environmental measures include a closed water circuit, an integral water management system, a biogas production facility, the use of sustainable building materials, the use of Renewable Energy Sources, an organic food production. The Lanxmeer project features far-reaching residential participation, inhabitants took active part in urban planning; in housing design; in communal balance; in the development of the green space and park; in the formation of a local energy company; in the city farm. In Eva-Lanxmeer the participation degree is about 70%. Other relevant phenomena recorded are: an approach based on internal motivation instead of external incentives; an active negotiation between promoters (NGO) and municipality on the vision for the development of the district; the presence of negotiators from Eva-Lanxmeer working permanently with the local authority; an active communication activity carried out at different levels both formal (newsletter, website) and informal (tam-tam between residents); a permanent exercise of overcoming dissent by weekly discussion between residents; a work on the quality of decision; the adoption of a deliberative democracy approach.

4.2_Other examples of cybernetic function

The cybernetic function has been recognised during the research in other sustainable districts such as BedZed (London); Vauban (Freiburg); Superblocks (Vitoria . Gasteiz) and Hammarby Sjostadt (Stockholm).

5_Endosomatic energy and the repositioning function

For centuries the dominant trend has been to minimize the physical effort through the use of machines. It seems that in the context of the energy transition we witness an albeit partial reverse of this trend. In fact, in the energy transition individuals must reposition themselves into a new energy (and social) system in which the relationship between the human body and the surrounding social reality changes deeply. The endosomatic (or personal) energy is activated in energy transition to face the challenges associated with the increased use of the body in the daily lives. This action – fulfilling what was called "the repositioning function" – is to be considered as a continuous work of psycho-physical adaptation. Repositioning function refers to phenomena such as:

- increased resort to muscular strength and the use of the body, not only in the field of mobility (walking or cycling), but also in other fields (such as an increased use of body warmth to face the low temperatures heating system);
- new attention toward practical issues of everyday life, such as food, health and physical well-being, waste management, etc.;
- spreading of energy literacy;
- spreading of a perception of self that is reframed within the energy system (e.g. you feel to be "physically" a part of the new energy system).

5.1_An example of repositioning function: the superblocks approach of Vitoria-Gasteiz (Spain)

The city of Vitoria Gasteiz developed and tested in the last years an integrated model to regulate traffic, access and urban space organisation through the definition of so-called "Superblocks". Superblocks model was developed in 2009 to free up space occupied by private cars in neighbourhoods and return it to the people. All street refurbishments carried out in the last years have applied the superblock model. A superblock is a geographical space that covers several city blocks. Vitoria-Gasteiz has reorganised the whole city into

68 superblocks. Private cars and public transport are kept outside of the superblocks, and the inner streets are redesigned to be used mainly by pedestrians. In the city there was an increased use of cycle and increased pedestrian movement (therefore an increased use of physical-endosomatic energy instead of gasoline, diesel fuel, etc.). Among citizens, there was also an emotional involvement of individuals in the project and a spread of awareness of the risks associated with climate change and the role of transport; volunteer action to promote new transportation scheme; change in lifestyle and physical "sacrifice" of the resident to obtain a radical change in transportation mode.

5.2_Other examples of repositioning function

The endosomatic function was active in other sustainable districts such as BedZed (London); Vauban (Freiburg); One Planet Sutton (Londo Borough of Sutton); Brussels Sustainable District (Brussels) and Augustenborg (Malmo).

6_Extrasomatic energy and the localization function

The localization function regards the way in which the change from carbon energy sources to low carbon and efficient technologies takes place. In the energy systems in transition, the technologies and the services for the production, transport and consumption of energy, become more accessible and visible to the people who are led to develop a direct control of energy systems, both at the personal and the collective level. Localisation function refers to phenomena such as:

- a localized production of energy;
- the activation of networks for the installation, the maintenance, and the technical assistance of the new sustainable technologies in a given area;
- the presence of technical skills also spread among the citizens;
- the shared ownership of the means of production and self-production of energy.

6.1_Example of localisation function Bo01, Malmo - Sweden

In the Western Harbour district polluted industrial areas have been replaced by office buildings and residential houses. The first development, Bo01, was designed to use and produce 100 per cent locally renewable energy over the course of a year. Buildings receive energy from solar, wind and a heat pump that extracts heat from an aquifer, facilitating seasonal storage of heat and cold water in the limestone strata underground. Bo01 was the first area to use a local green space factor to promote biodiversity, incorporating local vegetation, as well as rainwater through open storm water management and connection to the sea. The Western Harbour incorporates an eco-friendly transport system, with buses connecting the areas every five minutes. Bicycle lanes are easily accessible. The localisation function was recorded in the following phenomena: adapting the technology to production sectors and to local resources; training for architects and engineers; training for local technicians and installers; technical training of residents; access to networks of professionals for technical assistance; start-up of maintenance services; individual production of energy; daily use of low carbon technology by residents.

6.2_Other examples of localisation function

The localisation function was found in many other sustainable districts. Some example are: BedZed (London); Vauban (Freiburg); Hammarby Sjostadt (Stockholm), Eva Lnxmeere (Culamborg) and Ile de Nantes (Nantes).

7_The rise of Human factor in Anticipatory Sustainable Districts

Energy is the capacity to do a work. Milesecure 2050 shed a light on how human factor may be able to make energy transition work. Human energy is essential both to trigger energy transition, and to manage and overcome risks that energy systems in transition run. The research analysed this twofold role of human energy by interpreting each of its three dimensions in terms of a social action conductive to the success of the transition. What can be observed in the anticipatory sustainable districts, and that represents a discontinuity and a break with the past is, indeed, the rising of the human factor, from an ancillary or peripheral role (which occurs only downstream in the process of change), to a lead role in the change of energy systems (upstream in the process of change).

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Abstract

Urban pilot project is transforming micro-communities in the heart of Italy's Piedmont region. Concerto AL Piano is a European project aimed to demonstrate the economic and social benefits in investing in energy saving and renewable energy in the process of urban regeneration.
Thanks to the co-operation of the many players in this effort, as well as the support from the region, a previous project of a Photovoltaic Village was a success, and Alessandria became the largest PV village in Italy. Alessandria further promoted energy saving concepts, including encouraging sustainable construction under the banner of Concerto AL Piano.
The project includes a mix of interventions: the recovery of existing social housing, the construction of new eco-buildings and the provision of a district heating system in cogeneration. The project has been governed by a partnership between the local authority, public housing agencies, private building companies, universities and research centres. An urban regeneration process has been set-up to become a key action in the Strategic Energy Action Plan (SEAP) (1).
Concerto AL Piano in Alessandria has motivated many of the local residents to play a part in eco-construction and energy retrofit projects. Getting citizens involved in energy projects is proving to be the key to success for a region's effort to promote sustainable construction and energy saving systems.

CONCERTO AL PIANO: A SUSTAINABLE URBAN DEMONSTRATION PROJECT

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1_Introduction

The Concerto district is an area of multiple and complex characteristics: a peculiar structure of the population, a diversified settlement system for quality and density, a socio economic transformation, all elements that constitute a framework marked by symptoms of the transition from an "industrial" condition to a "post-industrial", as well as a transition from a "modern" socio-cultural in a "post-modern". The neighbourhood is fragmented both socially and spatially, characterized by elements rooted in time, consisting of strong ties and constraints of the traditional type and the other, in a continuous redefinition, subject to intermittent use by the population. The relationships between individuals appear only partially characterized by individualistic attitude: anonymity is not the rule. Often, in everyday life, there is a special relationship with the place where the experiences, the symbols, the deepest values bind the individual to the community of origin. All agree in defining this district as "human scale", a place where life is good, where there are no frenetic rhythms and where, therefore, are less pressing and present the problems of large urban areas (2). The Concerto district does not seem to register particular problems or deficiencies. Services, infrastructure and public transport appear good and the commercial network meet the residents' daily needs. The traditional forms of belonging persist and play an important and reassuring role of bonding personal recognition with the area. The research of local identity is manifested in an attempt to return to the past through the recovery of memories, celebrations, traditions of the past, and in the desire to have a viable community. Belonging to the community is a source of local attachment even when this Northern Italian region is not the place of origin, but the area where social relationships become day-by-day satisfactory.

Concerto AL Piano has a strong effect on the urban regeneration of the whole district. Above others, the reduced environmental impact and the local micro-climatic control through greening and absorption by green surfaces. The use of environmental friendly materials, the reduced fossil fuels consumption for space heating and sanitary hot water, the implementation of a large set of technologies and measures to save and reuse water, recycle waste, enlarge green surfaces and limit the speed of cars improve the micro-climate and the local environment.

Given these premises, the planning goals of Concerto AL Piano can be summarised as follows:

- High reduction of fossil fuel consumption in building renovation;
- Integration of renewable energies at the urban village scale
- District heating and co-generation as a network for the urban village
- Local team to promote information campaign, energy conservation scheme
- Municipal energy management and retrofit programme

Three main demonstration actions are developed in Concerto AL Piano (fig.1):

a. RETROFIT _ Energy Retrofitting at the district level

b. RENEW _ Energy Renovation of the existing village

c. NEW _ New Construction of a low-energy village

Figure 1. Plan of Concerto Al Piano Design.

2_The demonstration district

2.1_Energy Retrofitting at the district level

The Energy Retrofit Programme aimed at providing the Concerto district with an energy conservation scheme for 3000 dwellings, based on announcements in local newspapers and letters addressed to the inhabitants. A 20% of the audited buildings (48,000 m^2) were retrofitted following the scheme.

Over the global retrofit investment, inhabitants were asked to contribute up to the 65% of their energy rehabilitation costs. This was organised through local community tenders that have increased the popularity and penetration of the Energy Retrofit Programme at the city level.

The model used for estimating the energy demand of residential building stocks is based on an original methodology, investigated in various settings by the authors (3). It is based on data made available by the Italian census of buildings and dwellings, a specific section of the *population census*. In the census database a number of residential building features are recorded, such as: building age, number of floors, number of dwellings, proximity of buildings. The model is based on a building classification method, that considers a limited number of homogeneous building categories, which are relevant for the assessment of building energy performances. The *National census database* delivers the number of buildings and the dwelling surface area, taking into consideration features, such as building age, number of dwellings, and building proximity. These parameters have been selected to disaggregate the whole building stock into 32 *energy categories*. Building age can be related to the envelope thermo-physical performances, to the ratio of windows, and to the average height of dwellings. In addition, the number of dwellings and the building proximity affect the external surface/volume ratio, an important parameter for the overall energy performance of buildings. The energy demand of the building stock is calculated by associating the consumption indicators or energy performance ratings (kWh/m^{2}y) to each building category.

2.2_Energy renovation of the existing village

The existing social housing village was needing an urgent energy retrofit, due to the absence of thermal insulation and a very degraded envelope. Then, a deep renovation of 300 dwellings and one school took place, with the aim of reaching up to 50% reduction of the specific energy consumption. The complete refurbishment of 11 buildings belonging to the Social Housing Agency incorporated a wide range of measures: high thermal insulation; air tight windows and ventilation control; greenhouses and glazed balconies; individual heat meters and thermostatic valves; co-generation district heating.

An improvement of the external area is given by the green public square: a new aggregation centre of the urban village. The building outdoors are upgraded by introducing green measures and trees, creating a link between private and public green areas. A visible refurbishment involves the building facades, retrofitted using external fibre-wood insulation. Existing windows are replaced with new double glass, low emission and high performance windows. The south exposures are equipped with passive greenhouses to provide solar gains in winter, thus reducing energy consumptions for space heating.

Figure 2. Social housing settlement before and after renovation.

2.3_New construction of a low-energy village

The new low-energy village includes 104 dwellings and the elderly house for other 50 dwellings, adopting minimal space heating and DHW standards. In addition these dwellings make use of renewable energy: 200 m^2 of water solar collectors; 50 kWp of photovoltaic systems.

The design of the micro-climatic buildings is based on the atrium solution: two building blocks are linked together by transparent atrium to determine an intermediate climate in winter (fig. 3, left side). During summer, the large openings at the ground level and at the upper level guarantee adequate natural ventilation and shadow. The adopted solutions for the overall energy efficiency contemplate the typical measures for eco-buildings: from the walls' extra insulation (fibre paper), to the efficient lighting and water systems. Photovoltaic modules are installed as flat roofing system to cover dwelling electricity needs: 50 kW provide the peak power for summer electricity use. Solar water collectors provide the domesic hot water needs. 200 m^2 of solar collectors are hosted on flat roofs of the new buildings, as well.

The Elderly House is a four floors building, south oriented, with access on the main street. The building design gives privilege to a balance between indoor and outdoor environments, adopting innovative residential solutions for aged people. The space heating consumption of the new social elderly building will provide a 45% reduction compared to the Italian code (fig. 3, right side).

A newly built District Heating Network provides the heating and electricity in co-generation. One of the demonstration issues consists of showing the inhabitants how a central power station could appropriately fit in a populated residential district. A continuous power co-generator (250 kWe), running all the year long, is dedicated to the production of the base load heat and power demand. Heat is produced by an exhaust-water heat exchanger, at a temperature of 85 C°, and delivered to the district heating pipeline. The overall efficiency of the co-generator is above 70%. A natural gas burner (1.250 kWt), running in winter, matches the specific heat demand of the cold season. A plant remote control system drives the co-generator to adapt its power output following the heat demand, granting the highest possible efficiency. A remote control room gets each day the production data, with 15 minutes scansion, as well as any eventual out of order signal.

Figure 3. New village: Microclimatic house (left) and New social Elderly (right).

3_A training opportunity

Thanks to the training programmes offered by the area universities (Politecnico Torino) and government, citizens could easily learn about options that exist for their energy retrofit projects. Advisors helped them plan, build and rebuild high-efficiency housing and buildings. The training sessions involved many levels of participants. To improve the design quality of projects, architects and energy experts worked side-by-side to counsel citizens (fig.4).

In addition to citizens' training, Concerto AL Piano became the topic of an intensive university training activity that involved the students of Politecnico Torino. This project was studied as a "best practice" and a reference for training different topics of sustainable architecture: energy saving, bioclimatic architecture, sustainable and natural building materials, involvement of inhabitants in urban retrofit process. The students were committed in a "learning by doing" experience aimed at re-think, re-design or extend Concerto AL Piano, and explore different possible solutions. The training method consisted in a number of Scenario Workshops, simulating in classroom the urban regeneration strategy. Students were divided into "role" groups: public administrators, inhabitants, experts-architects, builders-investors. Each thematic group analysed problems, opportunities, strengths and weaknesses concerning the urban regeneration of Concerto AL Piano. New groups were formed, mixing all roles and starting a discussion between different stakeholders, in order to establish guidelines and targets for the urban regeneration plan, shared and approved by administrators, inhabitants, experts and investors. Thanks to this kind of *role game* the students had the experience of the complexity of Concerto projects and understood the importance of cooperation in a sustainable urban re-development process. Finally, all students went back to their role of *young architects* to re-elaborate their individual energy regeneration project.

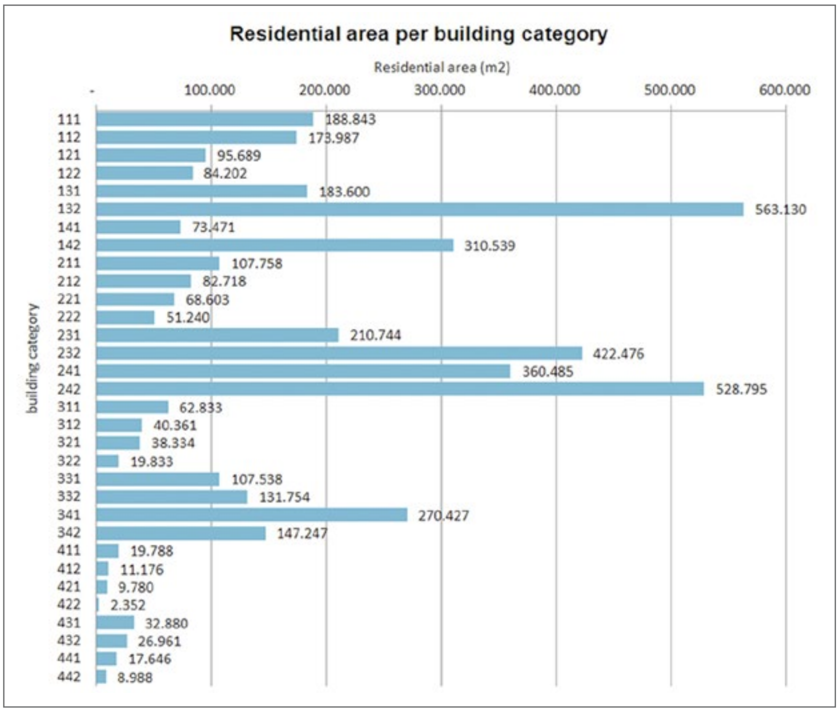
Figure 4. Training activities with students on project site and in the classroom.

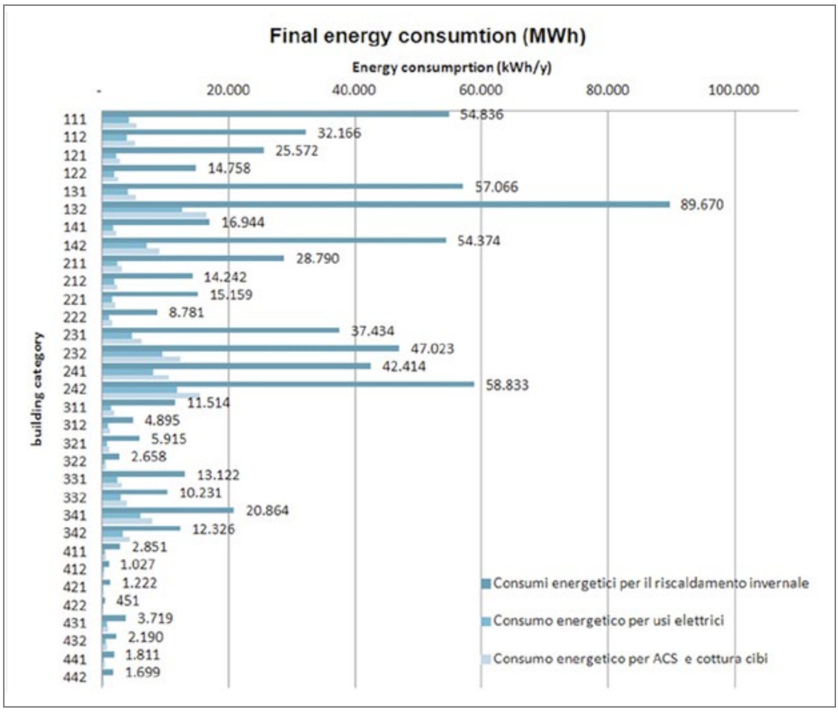
4_Monitoring and assessment

4.1_Results of retrofitting

Thanks to a public funding announcement, 42 energy retrofit interventions on residential buildings were funded, corresponding to 239 dwellings with an average area of 90 m^2 each. The total retrofitted surface was 21583 m^2, the total contribution disbursed amounted to EUR 269.760,00 with an average of 12,30 EUR/m^2. For each building a form was completed, with the main information concerning age of building, area, number of dwellings, description of energy retrofit interventions, photographs before and after refurbishment. An energy audit was also performed for each building, following the specific indication of national regulations for energy certification of buildings. The association to each building code of standard assessments of energy performance for heating, electrical components, hot water, and cooking uses, allows to estimate the energy consumption of the whole residential building stock. The simplified descriptive model allows a variety of analyses concerning the energy consumption of buildings, providing the indicators of average consumption for specific portions of the building stock or the distribution of

Figure 5. Retrofit analysis: assessment of residential area per building category (left) and final energy consumption of each building category.





buildings for different performance categories. The energy performance indicators are calculated by matching each category to a virtual building with standard characteristics that were established on the basis of a variety of sources (4-5).

4.2_Results of renovation

The instrumental monitoring under Concerto AL Piano on the RENEW component of demonstration involved the recording of temperature, humidity and natural lighting in a dwelling at the first floor of the building located in via Gandolfi No.15.

For this purpose four dataloggers have been used to survey and record the internal temperature, the relative humidity and the natural lighting levels of rooms and one datalogger to register the same measures outside the rooms. The test dwelling has a net surface of 96.8 m^2 and consists of: kitchen with adjoined greenhouse, living room facing South-West, three bedrooms, two bathrooms.

The monitoring results show some discomfort due to the high indoor temperatures, caused by an excessive supply of heat from boiler. The greenhouses return appropriate data, both in terms of temperature and humidity. The seasonal graphs identify a clear difference between greenhouse temperatures and outside temperatures during the heating season (until April 15). The analysis of temperatures in the summer period shows the alignment between the two temperatures, mainly determined by the tenants opening of greenhouses at the increase of internal temperature. During the heating season the trend lines point out a difference between the inside and outside temperatures of about 5-10 °C, showing that the greenhouse is working properly, leading to energy savings. The kitchen temperature is similar to the greenhouse temperature (6).

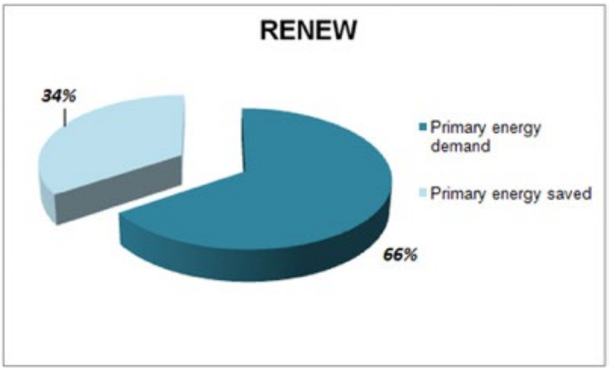
As a conclusion, the greenhouse solution applied in a such renovated dwelling provides suitable results. The comparison between the relative humidity values shows the absence of condensation and the acceptable range of relative humidity for the kitchen.

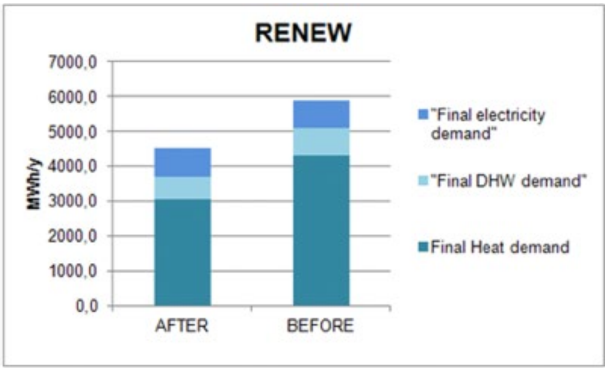
The energy consumption of the eleven existing buildings were evaluated during the design phase of Concerto AL Piano, and assessed after renovation, through energy bills and monitoring. This assessment took into consideration a value of 0,65 as efficiency coefficient of the original heating systems. After retrofitting, both district heating and the temperature control via thermostatic valves played a role in increasing the overall efficiency in energy use, raising from 0,65 to an overall value of 0,87.

Concerning domestic hot water, consumption data of natural gas were collected. These data did incorporate the consumption for cooking, estimated as the 7.1% of the total.

The final results highlighted the large variations among the buildings of RENEW, due to the different state of maintenance of buildings and to the original conditions of envelopes, some without thermal insulation and some others limited to 4 cm. The average energy saving of all buildings is 34%, the maximum is 48% and the minimum is 19% (Fig.6).

Figure 6. Expected consumption of Social Housing settlement after renovation: Primary energy demand (left) and final energy demand.





4.3_Results of new construction

Concerto AL Piano process started in 2005. While feeling that the market sooner or later would have required a significant quality improvement, the Italian builders appeared undecided on the energy consumption target values to be adopted. Between 2005 and 2010 in Italy a sudden alignment with low energy standards started, both in legislation, and in the market.

For the building partners of Alessandria, Concerto AL Piano represented an opportunity to tackle innovation, almost simultaneously to the legislative improvements. Nowadays, the energy targets for new buildings are much stricter compared with 2005, thus the results of this demonstration risk to be underestimated.

For the new buildings, the final energy consumption for heating and hot water, and the overall energy demand of housing were assessed. Electricity demand, assessed at 20 kWh/m^2 per year, corresponds to the average consumption for new buildings in Italy. Production of heat and electricity from solar energy is the result of a simulation, since users are not installed yet. The primary energy consumption has been worked out from the final energy of the buildings, taking into account the energy production by CHP plant and all production and distribution losses (fig 7).

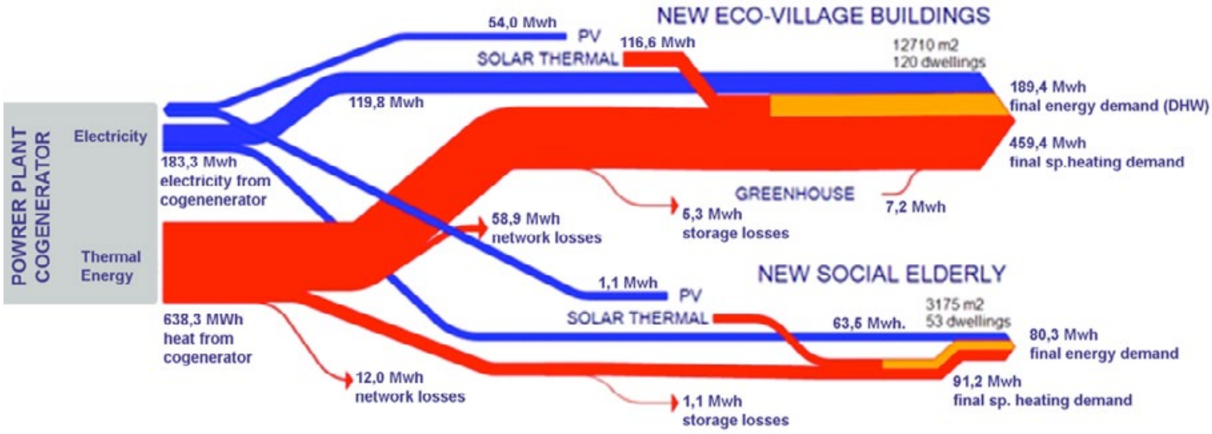


Figure 7. Energy balance of New buildings in Concerto AL Piano project.

4.4_Energy balance of Concerto AL Piano district

The new cogeneration power plant fuelled by natural gas, using typical rates of the plant, provides an overall energy production efficiency of 86.5%, of which 39.6% dedicated to the production of electricity and 46.9% to thermal energy. The evaluation of primary energy consumption for the existing settlement, before refurbishment, was converted from final energy into primary energy using the multiplier of 0.46, which corresponds to the overall efficiency of the Italian national electricity mix efficiency.

Heat losses from district heating networks are ranging between 10% to 16% (7) according to the length of the network. The value of 10% was adopted, based on the reduced size of the network. All buildings are then connected to the new district-heating network through heat exchangers that replace the old boilers, with extra losses estimated at 1%.

The energy consumption monitoring of each building has been performed, efficiency assessments of heating and electrical generation, of the district

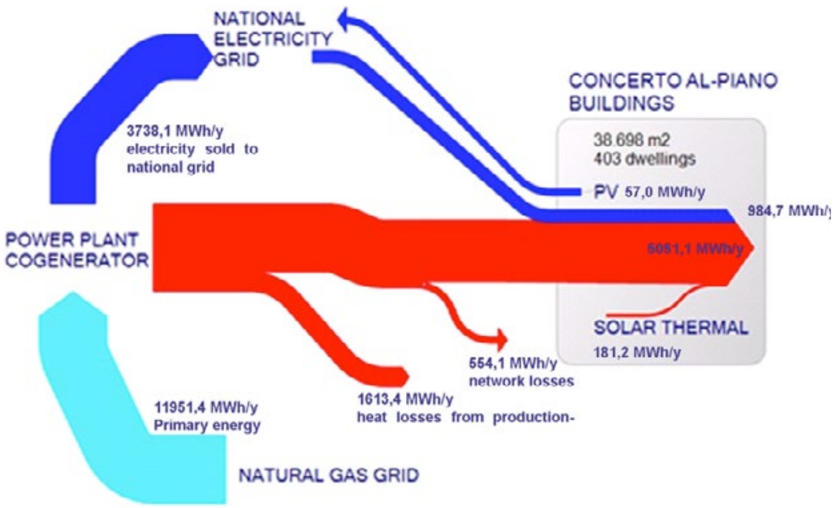


Figure 8. Concerto AL Piano Energy balance.

heating network, and of the cogeneration plant were performed with direct and indirect data (8). As shown in figure 8, the energy balance of the neighbourhood, supplied by the local district heating network, demonstrates a significant reduction in final energy consumptions.

5_Conclusions

This district of Alessandria is deeply renovated by Concerto AL Piano. The transformation is the result of a general improvement of social, urban and architectural environment of the area. The completion of urban voids, with the creation of the New Eco-Village and the New Social Elderly housing, improves the perception and the endowment of the district, otherwise incomplete. What undoubtedly has undergone significant transformation is the energy balance of the neighbourhood: the energy consumption of existing buildings was reduced of an average of 32%, with a potential of 48% that could be obtained with fine-tuning of the systems. New buildings represent the next generation in Alessandria aiming to reduce energy consumption even with unusual typological solutions for housing (building atrium).
Concerto AL Piano clearly shows that:

- the principle of *deep renovation* was applied, with the feasibility constraints related to a public housing market: the retrofitting performed by the Social Housing Agency was the most achievable, both in terms of technology and finance;
- the deep renovation of the existing building stock strongly affects the social and environmental quality of the area, much beyond a few high-quality new housing, that would make even more marked the difference between the old widespread housing and the new construction;
- the extensive energy savings over a large portion of building stock rises the awareness on environmental sustainability concepts, due to the bigger number of families involved;
- in a stagnant housing market, the *deep renovation* of the existing stock becomes a focus for building companies. The initial capital for refurbishment is lower and allows owners to invest even when flats and buildings are not completely deteriorated;

- since a deep building renovation is carried out with rather long cycles – ranging from 40-50 years – when starting a retrofitting one should always maximize the approach: quality, efficiency, saving. Having limited ambitions means that higher targets are compromised until another renovation cycle.

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Buildings for Post-Carbon Cities

A PRAGMATIC APPROACH FOR EMBODIED CARBON ESTIMATING IN BUILDINGS

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Abstract

Embodied Carbon (EC) estimating is driven by the development of Inventory of Carbon and Energy (ICE) in 2008 along with the initial information paper of Royal Institution of Chartered Surveyors (RICS) on the methodology to calculate EC in 2012. RICS's latest guidance note (RICS, 2014) suggests good practices to estimate EC during various stages of a construction project. However, EC estimating was daunting and laborious which is then simplified to some extent by the introduction of the UK Building Blackbook. Despite the efforts of institutions and researchers to encourage EC estimating, construction industry is slow to embed EC estimating in day-to-day business. Nevertheless, EC research is breaking its boundaries and embarking into new avenues. This paper adds new knowledge to the existing body of literature by presenting analyses of EC in different types of buildings including offices, residential buildings and educational buildings. Data were obtained from WRAP EC Database and presented in accordance with the element classification system of New Rules of Measurement (NRM). Descriptive statistics were used to analyse the data and inferences were made based on the findings. 'Carbon hotspots' or the carbon intensive elements in the selected three types of buildings were identified and an approach to estimate EC based on carbon hotspots is proposed in light of encouraging practices of EC estimating from an early stage of design process.

1_Introduction

EC emission consists of fuel related and process related carbon emissions (Hammond & Jones, 2011) which can be measured from raw material extraction (Cradle) till factory gate (Gate) or construction site (Site) or end of construction (Construction) or end of life (Grave) or even reuse/recover/recycling (Cradle). These are commonly termed as System Boundaries indicating from and to which point carbon emissions area measured. EC can also be categorised into three types: initial EC, recurring EC and end-of-life EC (Brandt, 2012; Shafiee & Topal, 2009). Initial EC is the emissions associated with the production of the building including raw material extraction, manufacturing, transport and construction; recurring EC includes emissions during the use of the building such as repair, maintenance and replacement; and end-of-life EC includes emissions associated with demolition of the building where benefits beyond system boundary is excluded from the three types as cradle to cradle analyses are very rare.

Latest climate conference COP21 in Paris highlighted the increasing significance of emissions reduction strategies where 187 countries including developing nations committed to reduce greenhouse gas emissions. Particularly, plans for sectoral (buildings, transport, industry, etc.) energy efficiency measures are also devised (COP21, 2015). Therefore, managing EC in construction projects is becoming significant at a national level. Improvements made to the Part L of the Building Regulations and zero carbon agenda aims at eliminating operational carbon from buildings. However, the Low Carbon Routemap for Built Environment of the UK sets 34% of carbon emissions reduction by 2020 followed by 50% and 80% reductions in 2025 and 2050 respectively to achieve targets of the UK Climate Change Act 2008. Of which, 21% reduction of EC emissions are expected by 2022 and a 39% reduction by 2050 (The Green Construction Board, 2013). This emphasise the need of reducing EC from buildings which forms an integral part in urban development. Nearly 70-80% of the capital cost and EC are committed during early design stages of construction projects (Asiedu & Gu, 1998; Kelly, Graham, & Male, 2015). On the other hand, as more cost and carbon is committed into the project, the reduction potential diminishes as possible design solutions are constrained by previous design decisions (RICS, 2014). This behaviour demands effective management of EC during early stages of design which in turn calls for EC estimating in the first place. The key source of EC estimating is ICE developed by (Hammond & Jones, 2008, 2011) which presents primary EC data for a series of base materials in kg of carbon dioxide emitted for each kg of material produced. This requires the building components to be decomposed into material, labour and plant; and then EC factor is applied to materials and fuel consumed by plant. Only difference in EC estimating compared to cost estimating being the exclusion of labour emissions (Langston & Langston, 2008). However, intense calculations involved in this method of EC estimating makes it complex and unapproachable (Ibn-Mohammed et al., 2013; Moncaster & Song, 2012). Also this method can only be applied to detailed stages of design where detailed specification is available and there is only limited academic research to aid decision-making at early stages of projects. For instance, Hitchin (2013) suggested that EC per GIFA for a new office building ranges from 600kgCO_2/m^2 to 1200kgCO_2/m^2 based on the case studies of 30 office buildings in the UK; Clark (2013) suggests that it ranges from 570kgCO_2/m^2 to 1350 kgCO_2/m^2. However, existing benchmarks are merely a guide and are not subject to rigorous scrutiny. Consequently, a method to encourage EC estimating during early design stages of construction projects is proposed in this paper.

2_Literature Review

2.1.1_Embodied Carbon Estimating

Cost estimating is one of the core duties of Quantity Surveyor (QS) in the construction industry in the UK and Construction Economists or Cost Engineers in other parts of the world. The process of cost estimating is well established and governed by industry standards like New Rules of Measurements (NRM). The most detailed estimate is known as Bill of Quantities (BoQ) with almost complete itemisation of all work related to a project. However, there are various other techniques to estimate cost during different stages of project as prescribed by NRM which is presented in Table 1. The table demonstrates the maturity of cost estimating techniques in the industry. On the other hand, carbon estimating is still evolving within the construction industry as it is a value added service provided by cost consultancy firms. Hence, the service is offered mostly by large construction firms. Carbon estimating is very similar to cost estimating though it evolved within the past decade. Similar techniques used in cost estimating can be applied in carbon estimating, however, there is an issue of robust EC data. Initially started with Hammond and Jones' Inventory of Carbon and Energy (ICE) and then it was simplified by

Table 1. Types of cost estimates prepared during various stages of a project (partially adopted from NRM1)

Franklin & Andrews (2011) UK Building Blackbook as it presents EC data in a similar fashion to a BoQ. Therefore, the Blackbook allows parallel estimating of project cost and EC. This is known as dual currency estimating where cost as per the financial currency of the country and EC measured in Kg as the second currency.

RIBA 2013 stages	RIBA 2007	Cost Plan/ Estimate	Technique
Preparation and Brief	Appraisal	Order of cost estimate	Single rate estimating - unit, superficial area
Concept Design	Concept	Formal cost plan 1	Single rate estimating - unit, superficial area, cube
Developed Design	Design Development	Formal cost plan 2	Elemental estimate
Technical Design	Technical Design/ Production Information	Formal cost plan 3/ Pre-tender estimate	Approximate quantities
	Tender Documentation	Bill of Quantities	
	Tender Action	Post-tender estimate	Adjusted Bill of Quantities

There are many EC estimating tools for early stage estimating and detailed stage estimating where access is either free or licensed. Even though all tools tend to perform the same function there are differences in input information, system boundary, outputs, methodology and data sources (Build Carbon Neutral, 2007; Phlorum, 2011; Rocky Mountain Institute 2009; TATA Steel, 2014; University of Minnesota, 2014). Each tool has its own limitations. Major limitation is the applicability of the tools which depends on the context and type of the building. This limitation becomes unavoidable for small scale projects with limited funds. Another variation among these tools is the system boundary. Most of the tools cover cradle to construction (excluding transport) system boundary while this is not clearly stated in few identified tools (Also see, Moncaster & Song, 2012). Many of these tools can be considered as a 'black box' as the underlying methodology is not transparent. Further, lack of standard methodology to estimate EC also causes variation in the outcome of the tools.

Nevertheless, the guidance note on EC estimating for construction projects published by RICS (2014) encourages estimating EC without relying on the available 'black box' tools. The initial guide on EC calculations was published in 2012 covering the cradle to gate system boundary. Later, RICS developed the guidance note to cover cradle to grave system boundary for EC estimating which remains as the latest guidance note providing step-by-step guide for EC estimating. The key sources needed for estimating EC include ICE, DEFRA Greenhouse Gas Conversion Factor Repository and BCIS Life Expectancy of Building Components. RICS (2014) classifies the project into four main stages namely: Product, Construction Process, Use and End-of Life stages which comply with TC350 EN 15978:2011 Standard for Life Cycle Assessment. This guidance note enables estimators to calculate EC of projects that can be executed in parallel to cost estimating of projects. Hence, the guidance note channels the competencies of a QS /estimator into EC estimating without investing on expensive EC estimating tools (Also see, Ashworth & Perera, (2015) for detailed account of measuring EC). In addition to that there are other carbon estimating tools ranges from early stages to detailed stages of design (see, Ekundayo, Perera, Udeaja, & Zhou, 2012; Ashworth & Perera, 2015;

Anderson, 2015). However, there is a lack of EC benchmarks to facilitate early design stage EC estimating unlike cost estimating (Ashworth & Perera, 2015; Victoria, Perera & Davies, 2015). Therefore, the concept of 'Carbon hotspots' become significant to assist early design stage EC estimating.

2.1.2_Carbon Hotspots

RICS (2014) defines 'Carbon hotspots' as the carbon significant aspect of a project which may not necessarily represent the most carbon intensive elements but also the elements where measurement data is easily available and greater levels of reduction is possible. Carbon hotspot can also be defined by 80:20 Pareto rule which claims that 80% of the effects are due to 20% of the causes. Similarly, carbon hotspots can be defined as 20% (or even more or less) of the building elements that are responsible for 80% of the EC emissions attributable to the building. Carbon hotspots may vary from one project to the other and from one building to the other due to heterogeneity of construction projects. Generally, Foundations, Frame, Roof, Walls and Floors are considered as carbon hotspots due to heavy use of steel and concrete in these elements. In addition to that even though it is reported that the building services contribute up to 25% of EC emissions (Hitchin, 2013), it is not widely regarded as a 'hotspot' as measuring building services during early design stages is a challenging and hence its reduction potential may be limited compared to other building elements (RICS, 2014). However, Cole and Kernan (1996) found that cladding finishes and building services are to be the biggest component of recurring carbon emissions of an office building. Hence, building services and finishes cannot be disregarded during design decision-making if it is a carbon significant element. Therefore, an indication of likely EC of building services should be included in early design stage estimates.

However, carbon hotspots of various types of buildings are not known yet. Further, it is also assumed that the hierarchy of carbon hotspots might change for different types of buildings (Ashworth & Perera, 2015). Different studies on EC of office buildings in the UK identified substructure and superstructure to be the most carbon significant elements (Clark, 2013; Halcrow Yolles, 2010a; 2010b, WRAP; Sturgis Associates, 2010, Victoria, Perera & Davies,

Building Elements	Building Parameters
Substructure	Footprint area
Frame	No. of storeys/total height of the building, Gross floor area
Floors	Gross floor area
Roof	Area of roof
Stairs and Ramp	No. of storeys/total height of the building
External doors and windows	Area of exterior doors/windows
External walls	Area of exterior wall
Internal Walls and Partitions	Gross floor area, Planning efficiency/ circulation space
Internal Doors	Planning efficiency/circulation space
Finishes	Total area finished (including partitions)
Services – mechanical	Gross floor area, Total enclosed volume
Services - electrical	Gross floor area, Transformer rating
External works	Gross site area

Table 2. Building elements influenced by building parameters (After Dell'Isola and Kirk (1981) and Collier (1984))

2015). Particularly, Frame, Upper Floors and External Wall in Superstructure are the commonly identified ‘hotspots’. Knowledge of carbon hotspots in different types of buildings simplifies the process of estimating and management of EC during early design stages. Further, design variables related to each identified carbon hotspot can be measured and elemental rates can be applied to derive the total EC of the building. Elemental rates can be either EC per Gross Internal Floor Area (GIFA) or EC per Element Unit quantity (EUQ). Table 2 lists the design variables influencing building element/s whereby EUQ is affected by related design variable. Nevertheless, benchmarks needed to be developed to facilitate this kind of elemental EC estimating.

3_Method

EC of offices, residences and educational buildings were analysed and presented in the paper. EC data were obtained from WRAP EC Database which is developed and maintained by WRAP and UK Green Building Council (2014). Database contained EC data of 48 office buildings, 53 residential buildings and 10 educational buildings. However, all the data could not be utilised due to the lack of elemental breakdown of the EC data. Therefore, resulting sample after screening includes 28 office buildings, 43 residential buildings and 4 educational buildings. Also the database contains data with different system boundaries in accordance with TC350 Standards: Cradle to Gate (A1-A3), Cradle to Site (A1-A4), Cradle to Construction (A1-A5), Cradle to Grave (A-C) and Cradle to Cradle (A-D). EC data of residential buildings and educational buildings are measured using a Cradle to Grave system boundary while office buildings are measured using a Cradle to Gate system boundary.

The data presented here uses a NRM element classification. The elements of the buildings are presented in six categories including Substructure, Superstructure structural, Superstructure non- structural, Envelope, Internal finishes and External works. EC with respect to External works were excluded from the study analysis as its EC component demonstrated a high variation in the dataset and it does not have an intricate relationship to the building concerned due to the fact that it varies depending on clients’ requirements and site conditions. Therefore, the results presented contains 5 types of elements - Substructure, Superstructure structural, Superstructure non-structural, Envelope and Internal finishes. Superstructure structural includes Frame, Upper Floors and Roof Structure; Superstructure non-structural includes Roof non-structural, Internal Walls and Partitions, Internal Doors; Envelope includes External Walls and Windows and External Doors; Internal Finishes included Wall Finishes, Floor Finishes and Ceiling Finishes.

As literature suggests carbon hotspots can be an ideal way of dealing with EC estimating during early stages of design (conceptual stage/detailed design stage according to RIBA plan of work 2013). Eventually, a conceptual model is proposed to estimate EC based on carbon significant elements of different types of buildings as follows:

$$EC = \Sigma_{i=1}^{n} EUQ_i \,.\, EUR_i + GIFA.\, UR_{Res} \quad (1)$$

Where,

EC	EC of the Building
EUQ_i	Element Unit Quantity of Element for the i[th] element
EUR_i	Element Unit Rate of Element for the i[th] element
1 to n	Carbon hotspots (or carbon intensive elements/elements responsible for 80% of emissions)
GIFA	Gross Internal Floor Area of the building
UR_{Res}	Unit Rate of Residual elements (elements responsible for 20% emissions)

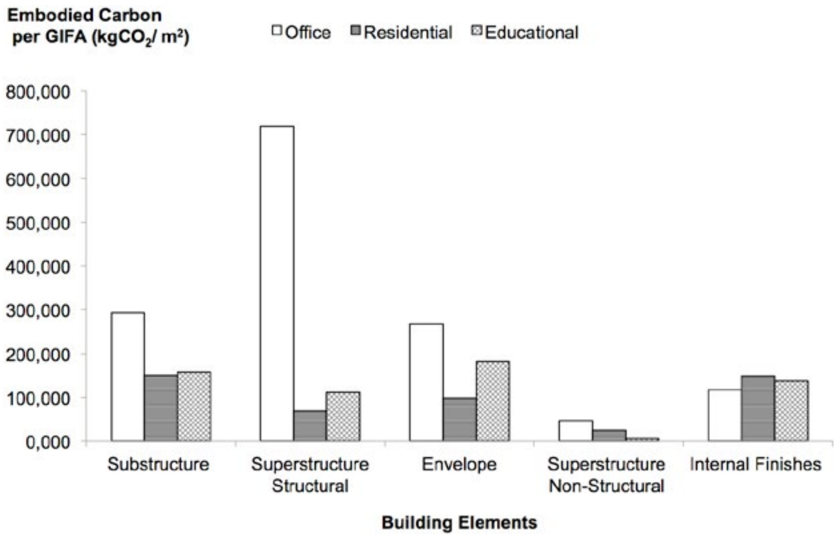
EC of each carbon significant element and the residual of the carbon insignificant elements are summed to arrive at the total EC of the building. EUQ is captured from conceptual drawings while EUR to be obtained from industry developed benchmarks which are however, lacking at present. The list of carbon hotspots will vary for different types of buildings. Hence, effort is made to identify the carbon hotspots of office, residential and educational buildings from the EC data obtained from WRAP database and the results are reported using descriptive statistics – mean, variance, minimum and maximum. Further, cumulative graphs are presented to identify the building elements that contribute up to 80% of the EC emissions (carbon hotspots) in each type of the building. Further comparisons were made between the selected three types of buildings to understand variation in EC component in different types of buildings.

4_Results and Discussion

Mean elemental EC analysis of offices, residential and educational buildings are presented in Figure 1. The sample of offices (28) and residential buildings (43) consisted of adequate sample size for inferences to be drawn. However, educational buildings sample consisted only four buildings which therefore, gives only an indication of the likely elemental EC values. Figure indicates that office buildings elemental EC values are higher than residential and educational buildings except in Internal Finishes. Especially, Superstructure - Structural EC is extremely high which includes Frame, Upper Floors and Roof Structure. Of the 28 office buildings, 18 buildings were above 5 stories while only 2 of the 43 residential buildings are above 5 stories. On the other hand, out of 4 educational buildings, 3 building are single storied and one is 2 storied. Therefore, influence of storey height in the sample of the three types of the buildings explains the drastic difference in elemental EC of office buildings from other two types. On the other hand, Internal Finishes were expected to be higher in office buildings due to the focus given on aesthetics and quality of finishes while the results suggest that office buildings elemental EC is the lowest among the three which is surprising.

Table 3 presents the findings from descriptive statistics of the elemental EC values of offices, residential and educational buildings. Accordingly, offices EC ranges from 458.91kgCO_2/m^2 Gross Internal Floor Area (GIFA) to 2,650.57kgCO_2/m^2 GIFA with a mean value of 1,445.36 kgCO_2/m^2 GIFA. The mean value of residential EC is 491.40kgCO_2/m^2 GIFA ranging from 313.59kgCO_2/m^2 to 886.44kgCO_2/m^2 GIFA. On the other hand, educational buildings have higher EC than residential but lower than offices. The mean EC in educational building is 590.74 $kgCO_2/m^2$ GIFA ranging from 497.30$kgCO_2/m^2$ GIFA to 690.26$kgCO_2/m^2$ GIFA. Office building sample has the highest variance while educational has the lowest. This demonstrates that the EC values of the educational buildings are closer to the mean. However, it should be noted that educational building sample consists of only 4 buildings and thus, no inferences can be made from the dataset. On the other hand, office buildings having higher variance than residential buildings showcases that the EC of office buildings has a wide range due to multiple design options.

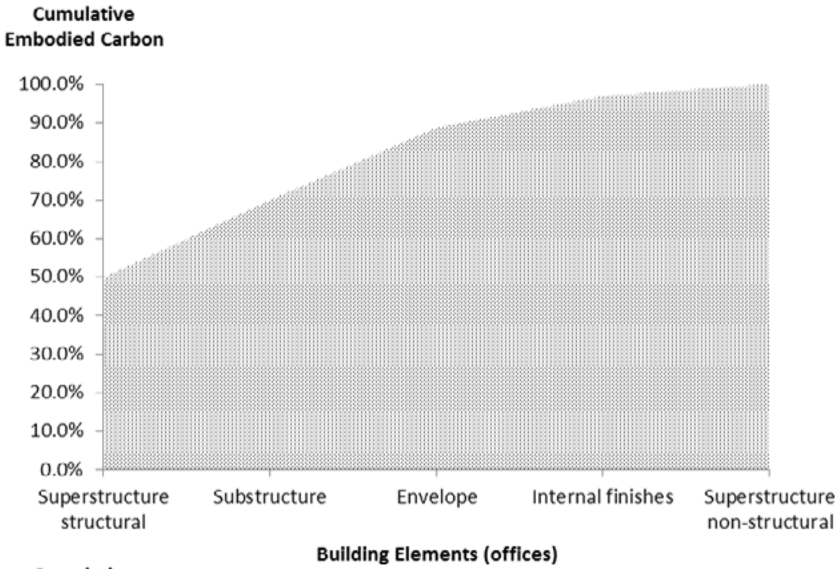
Figure 1. Elemental EC analysis of sample buildings

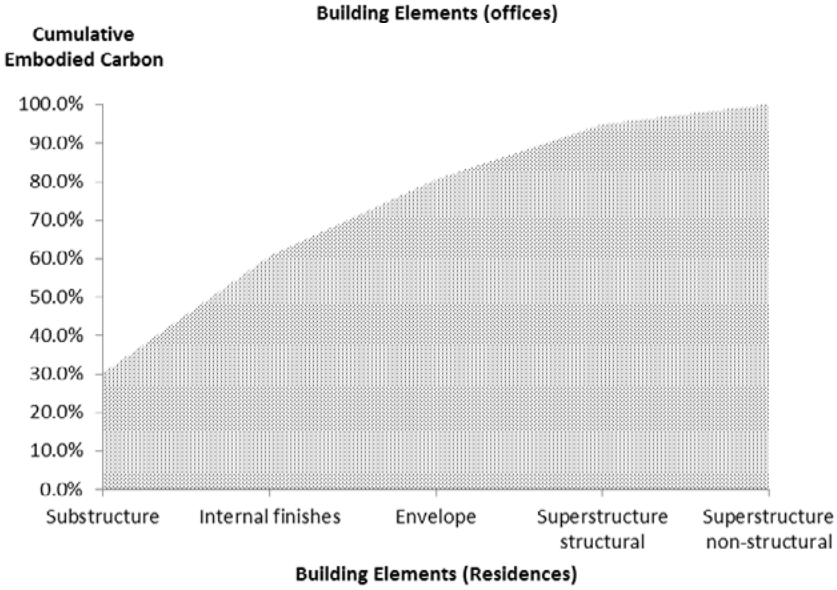


Building Type	Building Elements	Mean ($kgCO_2/m^2$ GIFA)	Variance	Minimum	Maximum	Count
Offices	Substructure	292.83	27,931.61	75.58	729.87	28
	Superstructure structural	719.54	80,183.14	168.99	1,439.73	28
	Envelope	268.64	24,405.63	72.09	625.96	28
	Superstructure non-structural	47.18	1,711.06	2.93	143.26	28
	Internal finishes	117.17	6,252.14	9.02	294.49	28
	Total EC/m^2 GIFA	1,445.36	265,360.84	458.91	2,650.57	28
Residential	Substructure	149.87	3,311.68	40.04	251.46	43
	Superstructure structural	69.36	4,211.13	8.77	239.51	43
	Envelope	98.24	4,154.47	29.13	243.69	43
	Superstructure non-structural	25.59	657.10	-	90.52	37
	Internal finishes	148.34	2,317.53	93.20	321.39	43
	Total EC/m^2 GIFA	491.40	18,450.99	313.59	886.44	43
Educational	Substructure	159.01	387.32	134.52	182.60	4
	Superstructure structural	111.00	1,006.24	65.36	138.87	4
	Envelope	181.76	857.42	152.82	222.43	4
	Superstructure non-structural	2.36	-	-	-	1
	Internal finishes	138.38	3,432.01	88.55	216.84	4
	Total EC/m^2 GIFA	590.74	7,136.92	497.30	690.26	4

Table 3. Descriptive statistics of elemental EC of sample buildings

Further, analysis of individual elements in the selected 3 types of buildings shows that in different types of buildings different building elements are carbon significant. For instance, the most carbon significant element in office buildings is Superstructure-Structural group element (Frame, Upper floors and Roof Structure); Substructure and Internal Finishes in residential buildings;





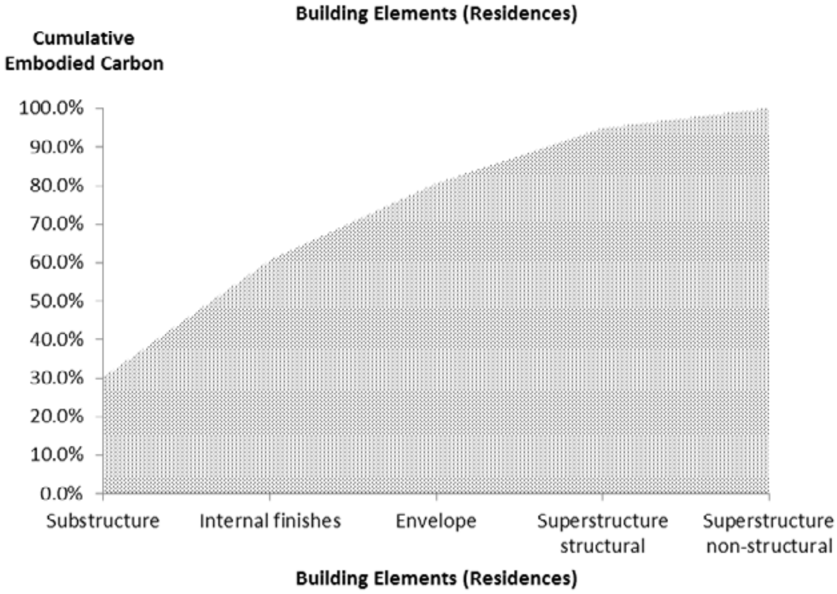


Figure 2. Carbon hotspot analysis of offices, residence and educational buildings

and Envelop in educational buildings. Therefore, the 3 samples were individually analysed to identify the 'carbon hotspots' or the building elements that are responsible for 80% of EC emissions in each type of building. This lead to the identification of the carbon significant elements of different types of buildings under consideration which in turn lead to early stage EC estimating

of buildings based on elemental EC benchmarks. Accordingly, in office buildings Frame, Upper Floor, Roof (Superstructure-Structural), Substructure and Envelop (part of it) are contributing up to 80% of EC emissions. On the other hand, Substructure, Internal Finishes and envelop are identified as the building elements contributing up to 80% of EC emissions in residential and educational buildings in different significance levels where substructure is the most carbon intensive element in residences while Envelope in educational buildings. This notably identifies that for different types of buildings level of carbon intensity of building elements varies. Therefore, gaining thorough knowledge of carbon intensive elements in different types of buildings is fundamental for successful early stage EC estimating and management.
Consequently, the proposed approach can be applied if the carbon intensive elements of various types of buildings are known and the respective elemental EC benchmarks are developed in a robust manner.
For instance, following equation can be applied for an office building:

$$EC = EUQ_F \,.\, EUR_F + EUQ_{UF} \,.\, EUR_{UF} + EUQ_R \,.\, EUR_R + EUQ_{Sub} \,.\, EUR_{Sub} + EUQ_E \,.\, EUR_E + GIFA \,.\, UR_{Res} \quad (2)$$

EC	EC of the Building
EUQ_F	Element Unit Quantity of Frame
EUR_F	Element Unit Rate of Frame
EUQ_{UF}	Element Unit Quantity of Upper Floor
EUR_{UF}	Element Unit Rate of Upper Floor
EUQ_R	Element Unit Quantity of Roof
EUR_R	Element Unit Rate of Roof
EUQ_{Sub}	Element Unit Quantity of Substructure
EUR_{Sub}	Element Unit Rate of Substructure
EUQ_E	Element Unit Quantity of Envelope
EUR_E	Element Unit Rate of Envelope
$GIFA$	Gross Internal Floor Area of the building
UR_{Res}	Unit Rate of Residual elements (Internal Finishes and Superstructure non-structural)

EUQ of Frame will be GIFA of the building; Upper Floor will be upper floor area; Roof will be roof area; substructure will be footprint area; envelope will be façade area. In this case, UR_{Res} for office buildings (EC of Internal Finishes and Superstructure non-structural) varies from 11.95 to 437.75 $kgCO_2/m^2$ GIFA, with a mean of 164.35 $kgCO_2/m^2$ GIFA. If, EURs are developed for different types of frame, foundations, roof, upper floors, envelope and the like, EC of different types of buildings can be computed at early stages of design. Hence, EC estimating can be carried out in parallel to cost estimating facilitating dual currency appraisals of construction projects. However, robust EC benchmarks are scarce at the moment in order to facilitate this type of estimating. Development of EC benchmarks for early design stage estimating is recognised as a fundamental need to manage carbon. Therefore, more research needed to be focused in these aspects despite the challenges in obtaining EC data.

5_Conclusions

There is an increasing level of significance attached to embodied carbon estimating as countries align themselves to achieving post COP21 carbon reduction targets. Although universally accepted EC estimating methodologies and rules are yet to be agreed, various data sources, guidance notes and tools have been developed to facilitate embodied carbon estimating at various stages of construction projects. However, early design stage embodied carbon estimating is challenging due to limited design information and lack of embodied carbon benchmarks. Therefore, a pragmatic approach to estimating embodied carbon with limited design data is proposed and the need for the development of robust embodied carbon benchmarks is highlighted. It is ideal to analyse all types of buildings and infrastructures, however, due to limitation in embodied carbon data only 3 types of buildings were explored – offices, residences and educational buildings. As expected, findings reveal that the hierarchy of carbon hotspots (elements responsible for 80% of embodied carbon emissions) vary for different types of buildings. The descending order of carbon hotspots of office buildings is Superstructure-structural and Substructure; residential buildings is Substructure, Internal Finishes and Envelope; residential buildings is Envelop, Substructure and Internal Finishes. Further, educational buildings EC per GIFA was higher than residential but lower than offices. Variance of EC per GIFA of office buildings was the highest while Variance of EC per GIFA of educational buildings was the lowest. However, educational building sample consists of only 4 buildings and thus, no inferences were made from the dataset. Higher variance of EC per GIFA in office buildings showcases that the EC of office buildings has a wide range due to multiple design options ranging from low rise to high rise whereas residences and educational buildings in the sample are mostly low rise. As a result, impact of building elements on different types of buildings varies. Hence, identifying carbon hotspots in different type of buildings pave the way for the proposed method of embodied carbon estimating during early design stages. EUQ of each carbon hotspot is measured and EUR of the respective element for different specification is applied. Summation of EC of the identified carbon hotspots and residual of carbon insignificant elements will give the embodied carbon content of the building. Measurements of EUQ can follow established building measurement practices like NRM. However, there is a lack of robust EC benchmarks which is a barrier for the application of the proposed method. Nevertheless, EC benchmarks are crucial to implement dual currency approach in construction projects. Elemental embodied carbon benchmarks are necessary for conceptual and detailed design stage carbon estimating to complement cost estimating for infirmed decision-making. Especially, buildings form an integral part of the society and thus, embodied carbon management plays an important role in urban sustainability and achieving carbon reduction targets agreed at COP21 in France in 2015.

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Abstract

Dry-hot arid climate has specific characteristic especially in Mediterranean area. Traditional houses offer good examples for adaptive and sustainable respond.
This paper aims to help promotion energy efficient architectural design in dry-hot arid climate by reviving the use of natural ventilation process (cross ventilation, single side ventilation 'stock ') and positive envelope properties of the traditional houses and urban traditional environment for courtyard housing clusters in a modern context. Such houses located in Damascus old city where traditionally renowned for their distinctive thermal comfort and adaptability.
Four traditional houses have been studied inside and outside the ancient walls of old Damascus city at traditional and semi modern urban environment. These houses are consist of two levels:
The first represents ground floor with heavy stone mass, the second represents the upper floor with light timber and dried mud structure mass. Each of them has different rooms size, windows and different forms of natural ventilation. Several monitoring data (air temperature, humidity and air velocity) were acquired during a hottest summer period, in parallel with occupancy surveys, besides the studies of two houses, with the help of the dynamic computer simulations.
The paper shows results of the air temperature and other parameters related to different structure materials (intervention as concrete), natural ventilation, windows (area and location) and influence of urban environments. The comfort conditions were calculated according to adaptive model of ASHRAE and subjective surveys. Furthermore, simulation modelling was utilized to Verified results to contribute as strategies for sustainable design in this area.

NATURAL VENTILATION AND THE EFFECT ON THERMAL COMFORT AS SUSTAINABLE STRATEGIES IN DRY HOT ARID CLIMATE

A case study in Damascus

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thermal comfort
traditional urban environment
temperature

1_Introduction

Using natural air dynamic phenomena to reach indoor comfort ventilation has been known since the early eras. The oldest architectures and engineering of the Middle East region have responded with such phenomena as a very good solution especially for dry-hot region (temperature and sun radiation height in the summer longest days light, big swing daily interval between day and night temperatures also seasonal between summer and winter). It realized the natural optimum comfortable temperature easily outside its urban environment and inside their houses during the most days of the yearlong. That was through equating with the volume adopting and the space taming with the different natural elements forces of the sun, atmosphere, biosphere and the local climate which are common in these days as passive design strategies and reducing energy consumption.
As consequences for all these prefaces and looking at the native architecture engineering civilization view obviously that no separation between architecture, engineering, environment's planning and the adopted human behaviour as they are in the old Damascus city. A real example comes over through heating's absorb surplus throughout the creation of the integrated texture (thermal mass combine with the natural ventilation). If the old city Damascus were as detached in smaller masses as it is now, the outer surfaces were

increased too much larger and exposed to the disturbances of cold-hot strikes waves and of heat either in winter or in summer. That means, each building needs an artificial ventilator. Therefore many researcher by worldwide specially in the Middle East and north Africa region have studied the passive control method of the traditional buildings which were comfort over years: Ahmad E. (1985) monitored the traditional courtyard house within six centuries old indigenous urban cluster and compared it to a modern detached house within a new developed urban quarter under summer and winter climate's conditions of Ghadames, Libya. Al-Hemiddi and Al-Saud (2001) studied experimentally the cooling in a building with an internal courtyard in a village house in Saudi Arabia. Changes in the courtyard ventilation were made by opening inner and/or outer windows in alternate ways during the day and night periods beside studied case covered and uncovered courtyard, closing it at on day time and open it at night time by tent. Abdulhak Mohammed (2007) Investigate environment factors impact on urban fabric and reflection on planning concept at new and old urban fabric at dry-hot climate in Damascus city, the result present the influence of old streets structure on ambient relative humidity which were more than new street structure about 8%, the courtyard relative humidity increase about 12-19% higher than new streets structures. Ambient air temperature for old fabric lower than new fabric about 3.3°Courtyard has big influence to reduce the environment factors inside it. Abdulhak Mohammed (2009) The research may contribute to the study of the effect of climatic factors on Human in the Republic of Yemen and to what extent he adapts to them in each region, the research has also worked on a bioclimatic evaluation study of some Yemeni cities, which contrast ins region differences, Sana'a (Cold - in Winter), 'Adan (Hot - Humid) and Say'un (Hot - Dry). Farghal- AMGAD (2011). This study focused on investigating the thermal environment and its effect on the comfort mechanism in the hot arid climate of Cairo, also the natural ventilation effect upon spring and autumn periods. Sadafi et al. (2011) studied the interaction between inner and outer thermal comfort. The contribution of inner courtyards to with the comfort of terraces housing in tropical climate was studied by model and measurements. At others region [studied thermal comfort for traditional buildings also courtyards. Taleghani, M Tenpierik, A Dobbelsteen (2012) investigate the effect of courtyards, atria(atrium) and sunspaces on indoor thermal comfort and energy consumption for heating and cooling. Sooleyon cho (2013) simulate the traditional IRAN courtyard and the effect of natural ventilation, improve energy plus model. The result emphasis that the courtyard has significant advantages on thermal performance of indoor space for dry climate and reduce cooling load by natural ventilation.

This research to investigate natural ventilation for traditional house that gives high energy efficiency in providing cool indoor air through ventilation (single sided, cross ventilation) and envelope behaviour (effect of natural materials and the intervention with concrete and other new materials)beside orientation and urban planning environment effect, with the procedure of measurements combination with simulation program model Design Builder and calibration, to improve middle east new residential city building through utilize passive cooling techniques to reach thermal comfort (temperature control) over interior condition. This strategies are utilized from sustainability viewpoint through reduce energy in a dry-hot arid region.

2_Investigation

2.1_Measurements

The basic selection depended on the difference between the ambient locations of typical Damascus traditional houses:
The first one represents the old urban city (compact fabric) with one or three courtyards for each house. The second represents the traditional houses at semi modern environment (surrounded by new high buildings, separate fabric) Figure (1.a) present that.
Each one consists of two levels (stories) with different orientation and different materials intervention. The cases have two levels contain heavy mass (stone and lime) at first level and light mass of timber structure with pressed dried mud and lime at the second (upper) one.
The first one that located at different part of the old urban city shows the influence of old urban fabric special for wind tunnel. BAIT FAKHRY AL BAROUDI Figure (1.b) shows its plan: Restoration works lime and mud mortar replaced by concrete, also hemp and clay replaced by bitumen roll; BAIT AL MOSLLI: house is still maintains old configuration and structure. BAB AL SALAM HOUSE: Configuration and structure have a lot of interventions also in design; every room got here a bath that means a lot of brick blocks used and plaster although concrete slab structure like others.
The Second: BAIT WARRD: the courtyard covered with sliding plastic roof this investigation have being with natural ventilation (cross ventilation, single side ventilation).

a

b

Figure 1.
a. cases location
b. BAIT FAKHRY AL BAROUDI, ground floor, first floor, section AA

2.1.1_Measurement setup

Several microclimate conditions measurements of indoor and outdoor courtyards have been done in summer period 2014. Measuring were made according to ASHRAE standard for temperature, relative humidity and air velocity. All data recorded every 5 minutes to get good indicator, the measurements made parallel with survey (ASHRAE 55). Air velocity collected manual corresponded with experiment measurements and surveys. The instruments position is based on three points:

- The first one is related to investigation of thermal comfort according to standard ASHRAE: positions are at (60, 110 cm) height (60 cm high for adaptive comfort model calculation) at the center of rooms and far away from walls at least 1m (position south wall means far 1m from wall); measurement intervals are 5 minutes.

- The second consideration is related to natural ventilation investigation, to evaluate air velocity behaviour and effect on comfort condition depending on opening windows position (one or two levels). In case of high roof's halls the measurements are divided into two levels: - first one to height 3m, - the second above 3m.
- The third one is related to analyse room orientation and floor level, besides its protection from direct solar radiation.

Rooms were chosen depending on their natural ventilation way: - cross ventilation (facing windows or adjacent), single side ventilation at one façade or - single side with stack (two levels of windows).

External climatic weather data are collected from the next weather station of the faculty of agriculture at Damascus University. It provides many weather data for every hour: temperature, relative humidity, wind speed, dew point, pressure and wind direction.

Operative temperature (T_{op}) is calculated in specific periods using air velocity manual data corresponding with experimental measurements of other physical parameters, in parallel with sensation survey based on PMV scale (7 point scale: from -3=cold, to +3=hot). For personal activity conditions and clothing, data collected from surveys are used for calculations: for relaxing conditions 1.2 met was set, for personal insulation clothes, the average thermal clothing resistance for all surveys of student and people (long trousers, short sleeves shirt, socks, and shoes) was used, equal to 0.58 clo.

Comfort analysis was performed using the Adaptive model proposed by ASHRAE-55 2010 Standard. This model allowed getting the effect of outdoor climate (and more specific the effect of natural ventilation) on occupants. This standard introduce the prevailing mean outdoor temperature (T_{mo}) as the input variable for the adaptive model. It is based on the arithmetic average of the mean daily outdoor temperatures over no fewer than 7 and no more than 30 sequential days prior to the day in question: for the period under study, T_{mo} is about 27.2 °C. The relations corresponding to the acceptable operative temperature (ASHRAE 55/2010) according to adaptive model ASHRAE handbook are:

- Upper 80% acceptability limit (°C) = 0.31 * Tmo +21.3 =29.73
- Upper 90% acceptability limit (°C) = 0.31* Tmo +20.3 =28.73
- Lower 80% acceptability limit (°C) = 0.31 * Tmo +14.3 =22.73
- Lower 90% acceptability limit (°C) = 0.31 * Tmo +15.3 =23.73

2.1.2_Data analysis

Use the equation editor (integrated within Microsoft Word) to insert equations as text wherever possible, or

The most collected data, recorded during of July 15th-22th and August 4th-13th, 2014, can be considered as a representative of a typical summer period. The weather conditions during those weeks were sunny, clear and hot. Maximum outside temperature, 39-41°C, was typical values during this period of the year or little bit higher about one or two degrees. About 1250 measurement was made, the total result about 100 measurements for every house.

Thermal performance: some comparison of thermal performances between all different houses under study, in order to evaluate influences of building type, that depend on urban environment, orientation, construction materials (traditional materials and new intervention systems), opening size and position, in order to investigate its impact on internal temperature and the natural ventilation behaviour on comfort.

COURTYARD: Typical temperature trends inside courtyard are reported in Figure (2), where houses with traditional structure gives best values for temperature and relative humidity (43%-63%) corresponding to courtyard size. The effect of a cover-up over the courtyard and urbanism observed at Bait Ward: high heat storage and a large thermal gradient: at ground level, with surrounding heavy mass, low stationary temperature were recorded (urbanism effect, on other hand reveres effect of tree that made up a kind of heat balance through temperature, relative humidity and low air flows), while at first floor very high values are measured due to greenhouse effect and to presence of light mass structure. The use of absorbing materials concrete for wall plaster and roof covering (Fakhry) increase temperature, while the activation of fountain in the same courtyard decreased temperature (min 1°C).

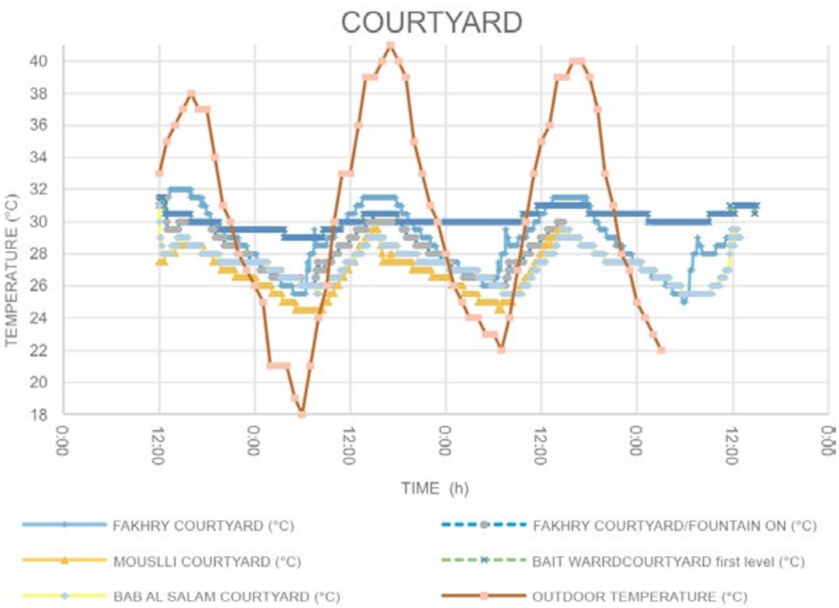


Figure 2. Temperature trends for different courtyards.

NORTH halls: Figure (3) shows the difference between two types of halls: Fakhry hall (3 m high, 75 cm underground) presents adjacent cross ventilation at one level windows causing more stationary temperature during day and night periods, Mouslli hall, with two windows level, have more temperature difference between day and night. Very important in this case is the impact of the intervention on structure using new materials (especially concrete) that increased the internal temperature of 1°C at least (Bab Al Salam).

First floor NORTH hall: Figure (4) the effect of cross natural ventilation decreases the temperature of 1°C to 3°C (at Fakhry hall due to high ceiling).

EAST halls: In this case the kind of structure impacts on the thermal behaviour due to stack single side natural ventilation for two levels which gives lower temperature (in Mouslli halls) compared to traditional houses structure Figure (5) present last result.

Figure 3. Temperature trends for north halls.

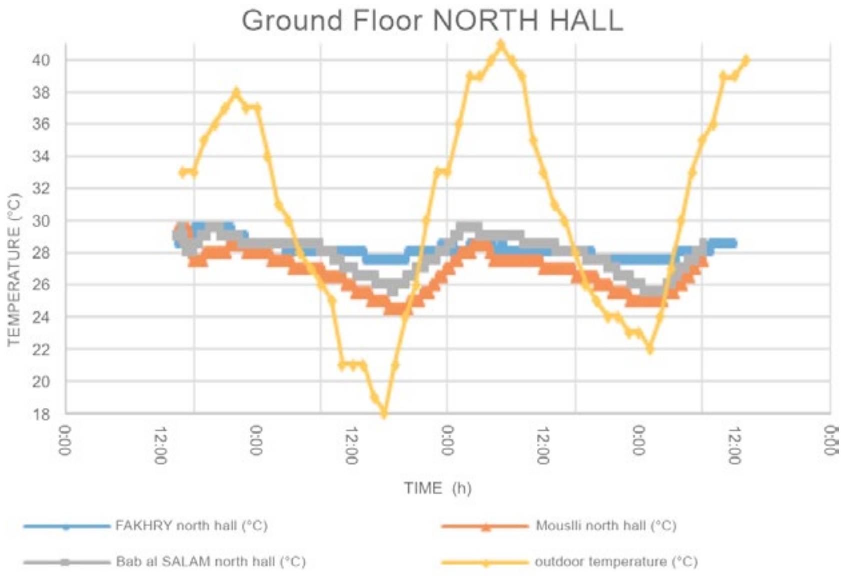


Figure 4. Temperature trends for 1st floor north halls.

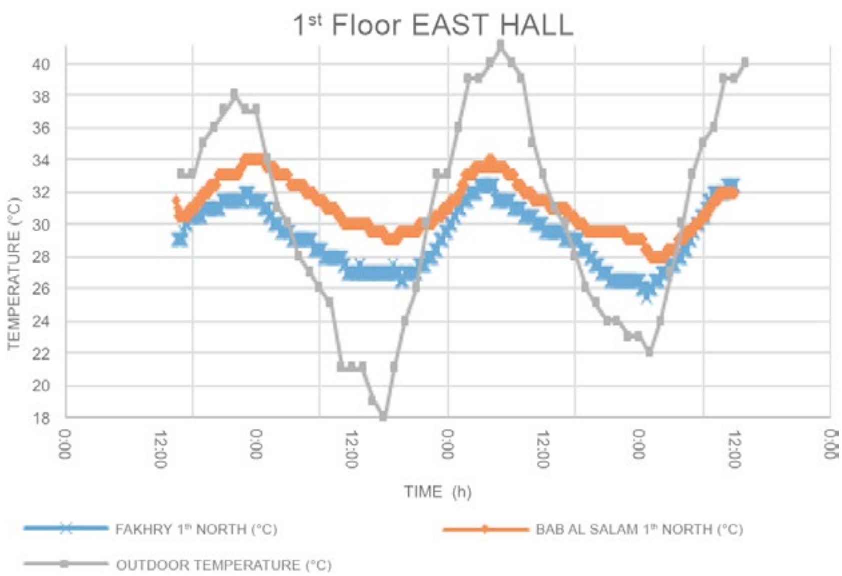
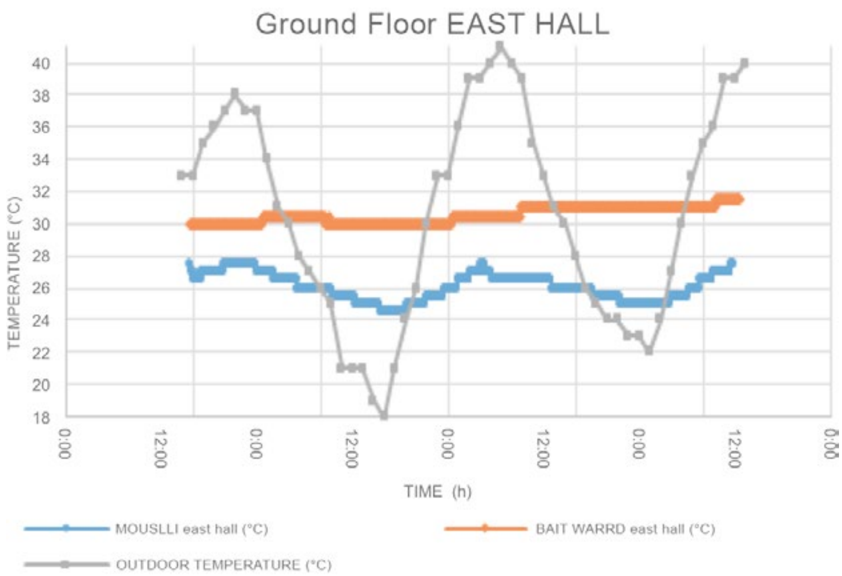


Figure 5. Temperature trends for east halls.



WEST halls: have the same impact as east halls. In the other hand at Bait Ward, roughly close to Mouslli house, measurements with sliding roof and big tree has shaded the whole courtyard and west halls for all days (reduce the urban environment effect). Fakhry hall (3m high, concrete intervention) increased temperature (min 3°C).

Thermal comfort: thermal sensation for occupancy based on collected survey data and thermal measurements, sensation results from survey data compared to measured temperature, Fakhry halls, in two conditions: non ventilation and with ventilation. Significant differences were found between non ventilation condition (comfort values higher than 2PMV sensation scale), and with ventilation condition (values ranging between 0 and 1scale) due to the effect of kind of the natural ventilation kind (cross "adjacent" ventilation; north hall, single side "stock" ventilation; south hall "two levels of windows"). Otherwise, the adaptive model is too closer to occupancy sensation for natural ventilation effect. Natural ventilation has great effect on human sensation and microclimate of space: in summer period natural ventilation gives at least 2°C lower temperature respect to the non-ventilation, depending on the kind of ventilation, orientation, structure, height and size and opening area. The adaptive model results: temperature measurements for different houses that fall within 90% limits of acceptability.

For North halls all cases fall within the acceptability limits of 90%, but Mouslli house presents better results, depending on structure and materials more than Bab al Salam.

For First floor north hall results confirm that cross ventilation increase acceptability limit roughly 20% to 25% comfort period Fakhry and in East hall the effect of natural ventilation increase 30% to 35% comfort period respect to closed space and also courtyard increase comfort period limits.

2.2_Simulation

The second step of this investigation to sophisticate building modelling simulation using measurements and monitoring data within dependable model (shows a good agreement between measurement and simulation using design Builder simulation program base depend on ASHRAE average for calibration accepted).

The two procedures are merged in order to develop a method for data evaluation in residential building with natural ventilation by getting more parameters and factor to evaluate and to provide a simple model for integration in residential building strategies to reduce load of building.

As a basic principle, results from experiments in traditional houses cannot be reproduced, as the heat storage of the building is a transient phenomenon. Using the building simulation, the measurements can be transferred into a harmonic oscillating model. With the parametric model, thermal building characteristics can be deduced from the simulation results. Thus, measured data are analysed by

- Evaluation of measured data based on standardized graphs and indices.
- Sophisticated building simulation using measured data and boundary conditions.

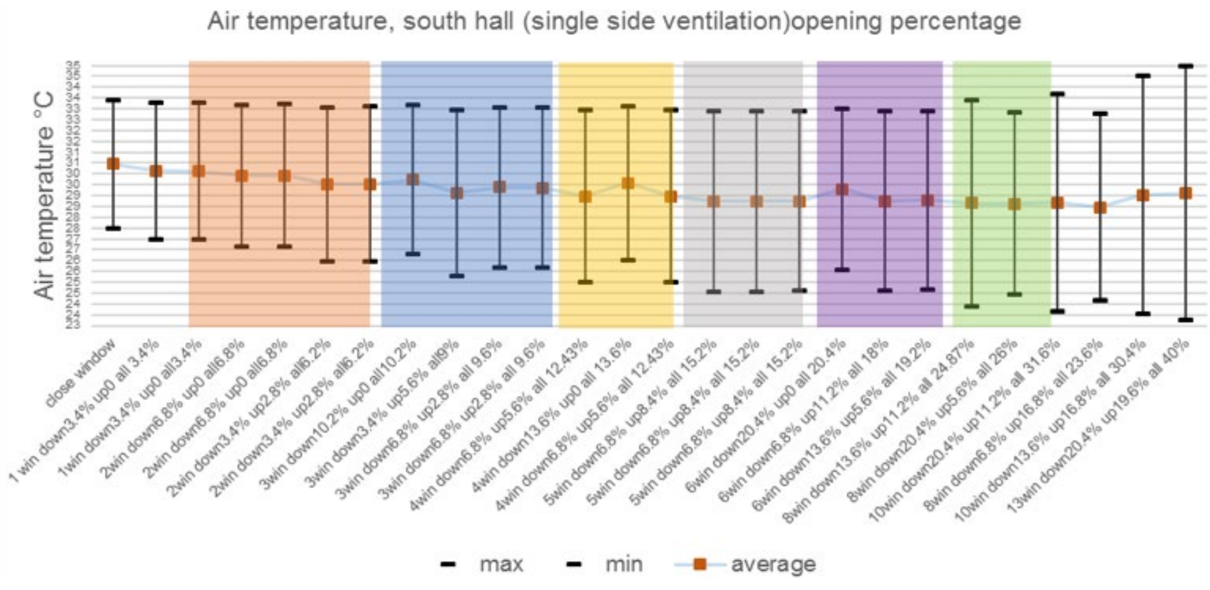
- Data evaluation of the results from the building simulation with standardized boundary conditions using a parametric model.

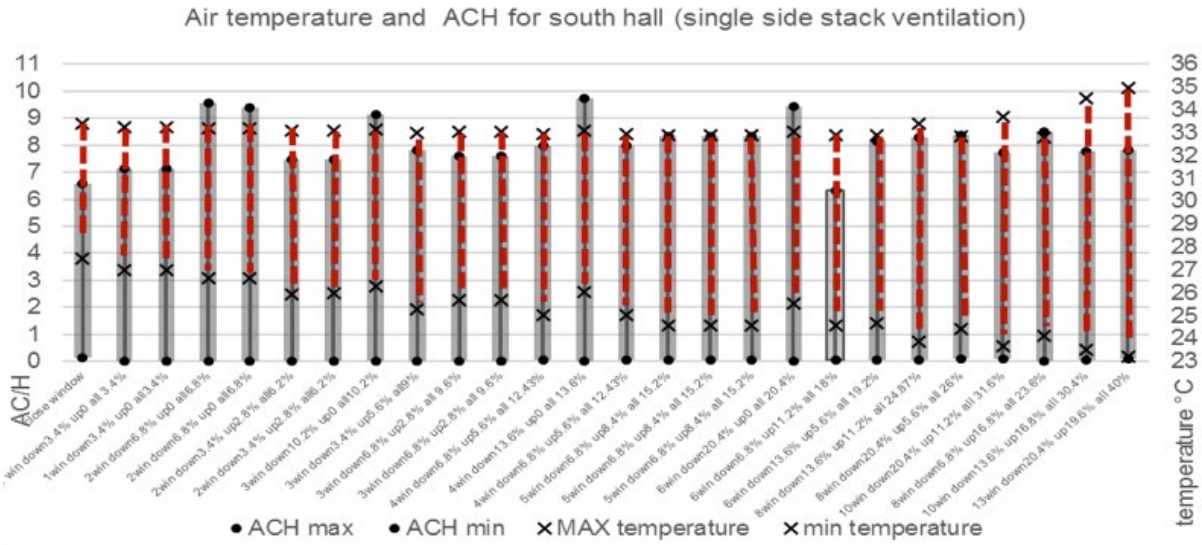
2.2.1_Natural ventilation

In modelling the natural ventilation effect there are some crucial points:
Natural ventilation: As most ventilation concepts are based on a free ventilation concept, the air change rates must be calculated. Due to the different driving forces (wind, buoyancy and fan driven ventilation (generate simple model for residential building), the design of free ventilation and inter zonal air exchange is complex.
Heat transfer: As the natural ventilation cools down the building construction, an accurate modelling of the convective heat transfer coefficient is essential for the simulation of natural ventilation.
The effectiveness of mass and natural ventilation in lowering the indoor daytime temperatures.
The difference between natural ventilation all day and night ventilation as passive strategies focus on thermal comfort.
The simulation made for summer period (applied EPW file of weather data collected before) for July and August.

Single Side Stack Ventilation integrated Investigation: South hall ventilation depend on single stack ventilation, for more explanation for stack behaviour, more simulation has done to deduce the effective area and percentage. South hall has north façade consists of thirteen windows divided for two levels under level with six windows and upper levels with seven windows.It has divided for five vertical parts through alternate configuration between opaque and transparent windows which started by 8% opaque, 25% transparent windows, 25% opaque, 25% transparent windows, 17% opaque.
Consequences: air flow throw opening area, position and orientation:
Best natural ventilation influence for over 20% opening percentage: up level opening about 70% and down level opening about 30%.
Best natural ventilation influence for fewer than 20% opening percentage: up level opening about 60-65% and down level opening percentage about 40-35%. Figure (6) presents latest results.

Figure 6. Air temperature related to opening area for Single side stack ventilation.





The influence of opening areas on air temperature present at Figure (7) all cases have roughly equal max air temperature except the high percentage of opening, the minimum air temperature proportion with opening percentage specially with high percentage for upper level opening. Deduced from previous Figure [7] single stack ventilation achieve lower temperature with lower ACH than ordinary opening and lower opening percentage.

Normal opening design (that has one level of windows has equal air temperature results for utilizing single side (stack) ventilation but with reducing opening about 50% Figure (7).

On other hand, this result depends also on thermal mass and the behaviour of heavy mass properties.

Figure 7. Relation between inside air temperatures with air change inside hall per hour.

3_Conclusion and future work

Analysis inside courtyard shows the importance of the traditional materials structure and the ancient urbanism (compact fabric, Mouslli) besides the size and shaded area (Bab Al Salam), the presence of trees and another important factor as the influence of fountain.

Building structure (heavy thermal mass at the ground floor) and ceiling height have main influence on thermal comfort.

Opening area and positions have significant influence on natural ventilation effective, that present in particular at stack effect (two level of windows in Fakhry south hall with elevation of about 8 m), cross ventilation (in west Mouslli hall with cross ventilation adjacent windows) better than single side ventilation (in west Fakhry hall).

Using the adaptive model gets closer results to human sensation survey, which shows a great variability of subjective sensations bringing to consider more relevant of adaptive model Figure (8) presents the effective percentage of each elements on thermal comfort. Depending said the compact fabric planning has best performance for dry-hot arid climate housing (Mouslli).

Thermal mass (heavy mass) utilize natural sustainability materials gives more comfort for occupancy, which increase by merging with natural ventilation as passive cooling strategies.

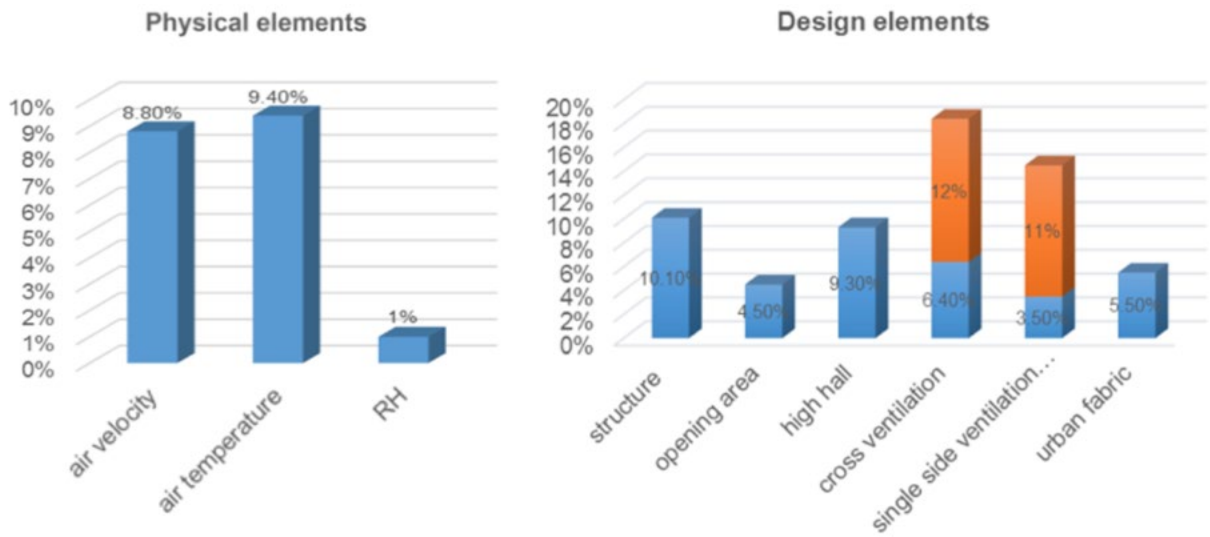


Figure 8. Elements effective percentage on thermal comfort.

Effective factors on natural ventilation proportional and thermal comfort volume [the rate between height and area (depth), WWR% (depend on façade) is the same for each kind of natural ventilation.

Divided WWR to more than one area as possible, for better interior air flow influence on occupant thermal comfort.

Single side (stack) natural ventilation has more influence than single normal ventilation (east hall MOUSLLI, BAIT WARRD).

Future work, needs more investigation about the influence of natural ventilation during very hot summer period as expressional years 2015th consequences for global warming and earth heating increase effect to achieve flexible designing and planning for more changing also for winter period.

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METHOD AND TOOLS FOR ASSESSMENT OF ENERGY PERFORMANCE OF BUILDINGS

Case Study

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Abstract

The application of whole "BEPS-Building Energy Performance Simulation" models is being increasingly used as a method of information management, as well as a project management tool all along the life cycle of energy efficient buildings.
This study enters in the framework of the European project TRIBUTE (2013-2017). The goal of this project is the reduction of the gap between predicted and measured energy performance of buildings, through the improvement of the prediction capacity of energy modeling and simulation tools.
This improvement will take into account all key parameters that influence the energy performance of buildings, like the behavior of occupants, the key components of buildings (envelope, HVAC systems, control systems) and the aging of materials.
For this purpose, three buildings have been selected, especially a public library in Torino that is the purpose of this paper.
This paper presents, in particularly:

- *the synthesis of energy audit of the building realized in order to collect input data indispensable for simulations;*
- *the simulation tool used and the first results of energy performance simulations;*
- *the deployment of comfort sensors (temperature, humidity, luminosity) in the building and the protocol used to follow real-time measurements;*
- *the connection between real-time measurements, and the energy simulation model.*

For existing buildings, this involves the use of the best and most faithful modeling in returning data through the development of better technology for on-line identification of key parameters of buildings and automatic scaling in real-time systems than at present BEPS of building-system.

1_Introduction

The use of templates to "BEPS-Building Energy Performance" is soaring as useful energy information management emanating from the buildings that are monitored. Analyzing and processing this information you can check the operation of the energy system of the building, evaluate performance and diagnose errors and anomalies, intervene where appropriate allowing for a systematic approach to continuous improvement of its energy efficiency. Nowadays, the analyses produced by such simulation models show a remarkable discrepancy compared with the real situation and this limits and conditions the practical application.
As mentioned, with funding from the European project TRIBUTE was commissioned a case study of energy audit, energy dynamics modeling, cost-benefit evaluation of retrofit options, installation of smart metering systems thermal and electric, integrated into existing BEMS systems at a library in the Città di Torino. Energy optimizations are being implemented through remote system via web and monitoring installations (temperature, humidity, light, CO_2, occupation of space).

2_Description

The project aims to minimize the gap between the simulated and the real ones, energy performance by improving the predictive ability of existing measuring systems, monitoring and control of energy performances of buildings by developing a "smart energy monitoring and control system" in Italo Calvino's Library in Torino. In addition, the project TRIBUTE plans to extend the use of the instruments of BEPS even during management of buildings (as well as for the design). For existing buildings, this involves using the best and most faithful modeling systems in returning data through the development of better technology to identify key parameters of buildings and online real-time automatic scaling of BEPS systems than in the present state of building-system. In addition, an application is under development by Building Health Management able to compare the measured data with those predicted and detect any deviations and failures. The measurement systems, accounting, monitoring and control of heat and electricity, using open and interoperable protocols, are provided by the partner Schneider Electric (with experimental sensors integration provided by other partners), while dynamic energy simulation is made through the IDA_ICE modeling software.

3_Testing site

In order to validate and prove the replicability of the TRIBUTE, smart metering systems, accounting, monitoring and control of heat and electricity were installed (partly being implemented) in three different buildings, located in three different States with different climatic conditions: the library Italo Calvino in Torino (Italy), a block office in La Rochelle (France) and the Living-lab of IBM Headquarters (Ireland).

The building of Torino, located on the right side of the river Dora in a central area, was built in the nineteenth century and was originally a tannery. In 2003, the city of Turin decided to transfer to it the neighborhood library and designed and implemented a complete renovation. The works were completed in late 2006 and is functioning as a library since 2007.

Figure 1. Italo Calvino Library - Lungo Dora Agrigento 94 Torino

The library has approximately 14x16m rectangular base dimension, on three floors and a basement, oriented with the northeast side facing towards the river Dora. The main building is in full load-bearing brickwork, while the side wings have reinforced concrete and masonry bricks for a total of 50 cm thick. The wooden roof is covered with tiles. The frames are made of aluminium with double glazing.

3.1_Time schedule and occupancy

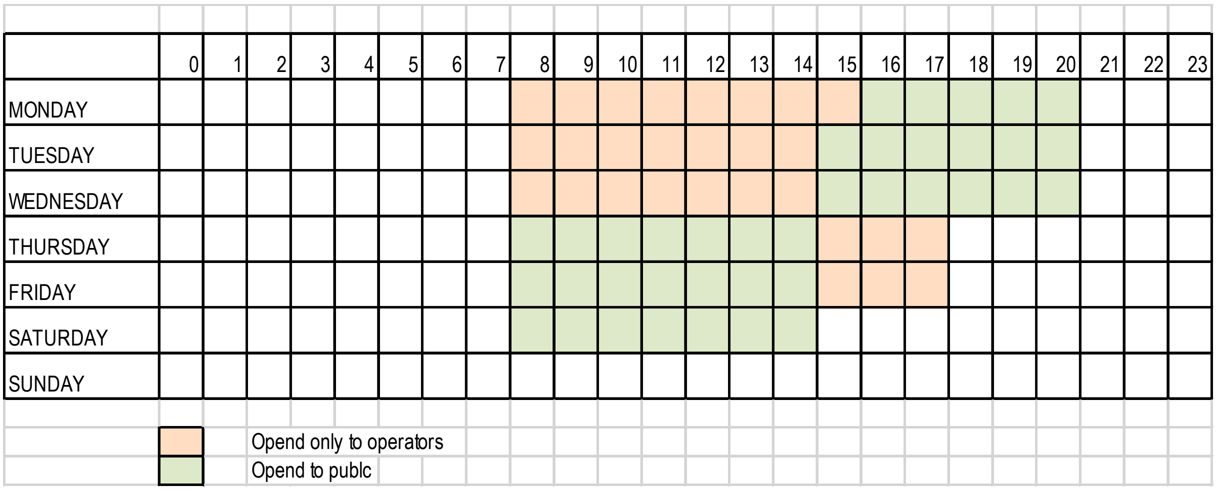
Usual occupancy of the building is:

- N° 3 operators, present during working hours
- N° 100 people average present when reading rooms are opened to public
- 140 people maximum occupancy in the meeting room, which could be used both during working hours and in other period.

Operational time scheduling of the library is:

- Monday 8:00 to 15:00 only operators, 15:00 to 19:45 public
- Tuesday and Wednesday 8:00 to 14:00 only operators, 14:00 to 19:45 public
- Thursday and Friday 8:00 to 14:00 public, 14:00 to 17:00 only operators
- Saturday 8:00 to 14:00 public

Figure 2. Time schedule



Occupants can influence infiltration through the opening of windows, increase internal heat gain by neglecting the solar blind status. Moreover, occupants are the driving force behind electricity as well as domestic hot water consumption. This integrated relationship between the occupants and the building also reveals the complexity incorporated in modelling occupancy behaviour for the purpose of bridging the gap between initial design and the final built energy consumption performance. The complexity of capturing the occupant behaviour still remains a part of the challenge in occupancy modelling.

4_Energy audit

The energy audit aims at identifying as a building and who is using the energy, what are the fees for the supply of energy, and the identification of improvements to reduce energy consumption. The scope of work undertaken with an energy audit results essentially from the study objectives and available resources. In ns. If you performed the first two levels, as defined by ASHRAE standards, while the third level (third-level audits focus on optimizing plant potential and possibilities of economic investment, based on the analysis, based on data collected and monitoring performed and in progress, providing data or data fields more detailed and more comprehensive engineering analysis).

4.1_Electrical system

There is a single point of low voltage electrical connection, placed in a reception booth outside the building, bargaining power of 250kW, three-phase + neutral 400V. The main electrical panel, as well as the UPS group from 20kVA and the electrical safety circuits are installed in the booth on the second floor. Outside the building there are a generating set 150kVA and refrigeration unit from 411, 6kWt (power 164kWe). The lighting system is made by bodies illuminated with fluorescent lamps and electronic ballasts (partly with adjustable power).

Figure 3. The multimedia room

4.2_Air conditioning system

Water heating plant consists of two gas boilers, rated at 274kWt each. The refrigerating unit is the thermal capacity of 411,6kWt. There are different systems in different parts of the building: two-pipe fan-coil and fresh air in the Conference room and reading rooms-two pipe fan-coil in offices, hallways and rooms that are not open to the public-radiators in the restrooms. The fan-coil have on board an electronic temperature sensor, which regulates water valve opening/closing and has three levels of emission regulation air speed. Hot water given the modest consumption, consists of electric boilers installed in individual blocks services.

Figure 4. Pumping room

4.3_Annual energy consumption

Water heating plant consists of two Natural gas consumption data is grouped in 6 years, following heating seasons, i.e. from October 2007 to September 2013. Electrical consumption data is splitted in hours, months or years, from January 2009 to December 2012. Only three complete consumption years, precisely from October 2009 to September 2012, are therefore available. We used the 9,883721 kWh/Sm^3 calorific value, to transform Standard Cubic Meters of natural gas consumption to kWh of equivalent energy used in the building. To calculate specific energy consumption indexes we divided energy pictures by 2.820 m^2 of total Gross Floor Area and 11.632 m^3 of Total Gross Volume.

Table 1. Annual Energy Consumption

Themal season	Natural Gas Consumption Data from Provider IRIDE				Electricity Consumption Data from Provider IRIDE			Total Consumption		
	Sm3	kWh/y	kWh/m^2/y	kWh/m^3/y	kWh/y	kWh/m^2/y	kWh/m^3/y	kWh	kWh/m^2/y	kWh/m^3/y
ott 07 - sett 08	15.575	153.939	72	13						
ott-08 - sett 09	16.630	164.366	77	14						
ott 09 - sett 10	21.223	209.762	99	18	179.688	64	15	389.450	138	33
ott 10 - sett 11	20.011	197.783	93	17	172.141	61	15	369.924	131	32
ott 11 - sett 12	20.305	200.689	94	17	140.528	50	12	341.217	121	29
ott 12 - sett 13	23.815	235.381	111	20						

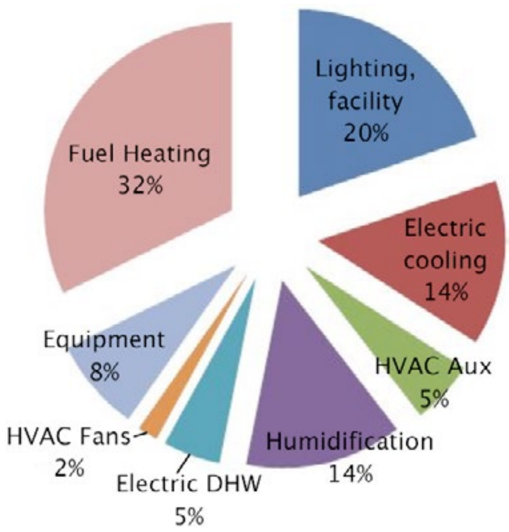


Figure 5. Simulated energy distribution

4.4_Possible improvements

The interventions suggested by the audit mainly concern the implementation of building automation system of the building, with a series of other measures, such as: the replacement mixer high efficiency heat exchanger with UTA, replacing the circulating pumps with variable delivery, installation of dampers on the primary air flow and return pipes, replacement of the fan-coil water regulation system and existing anti-shoplifting system connection (comes with software that counts and records the number people in and out of the library) to the new BEMS.

5_Energy dynamic simulation

The template, with IDA-ICE software was created starting from a basic AutoCad Revit BIM and ASHRAE standards.

At the time it was completed the entire energy model and are experiencing trust with data in our possession and with those who are arriving from measuring and monitoring system installed this spring.

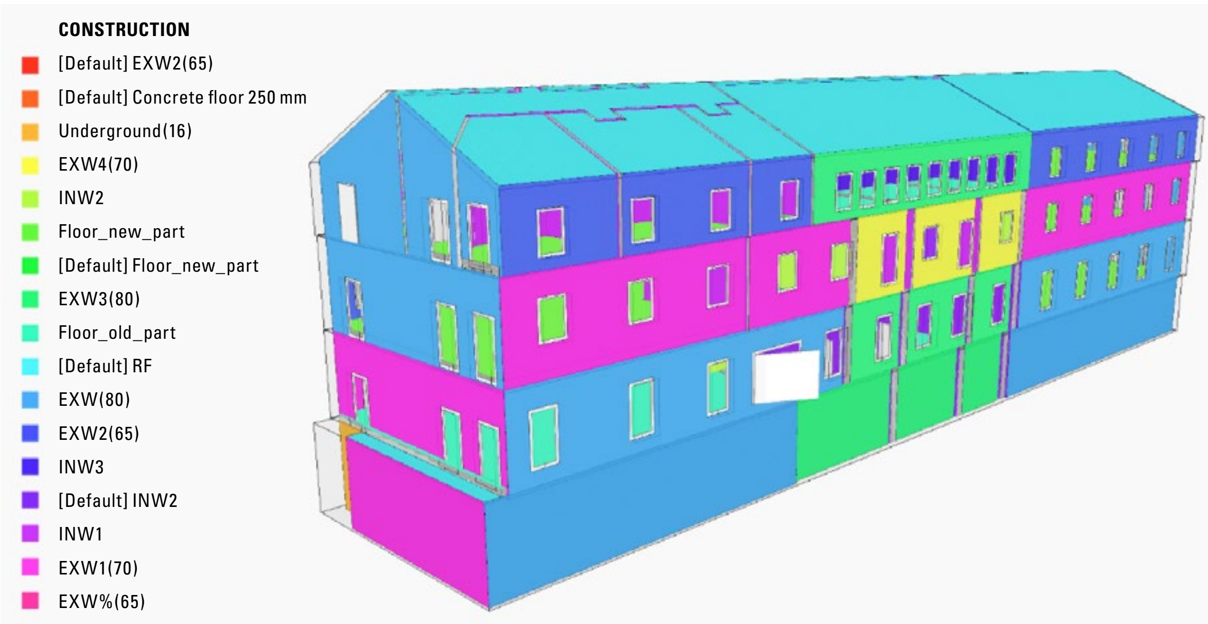


Figure 6. Modeling of building components

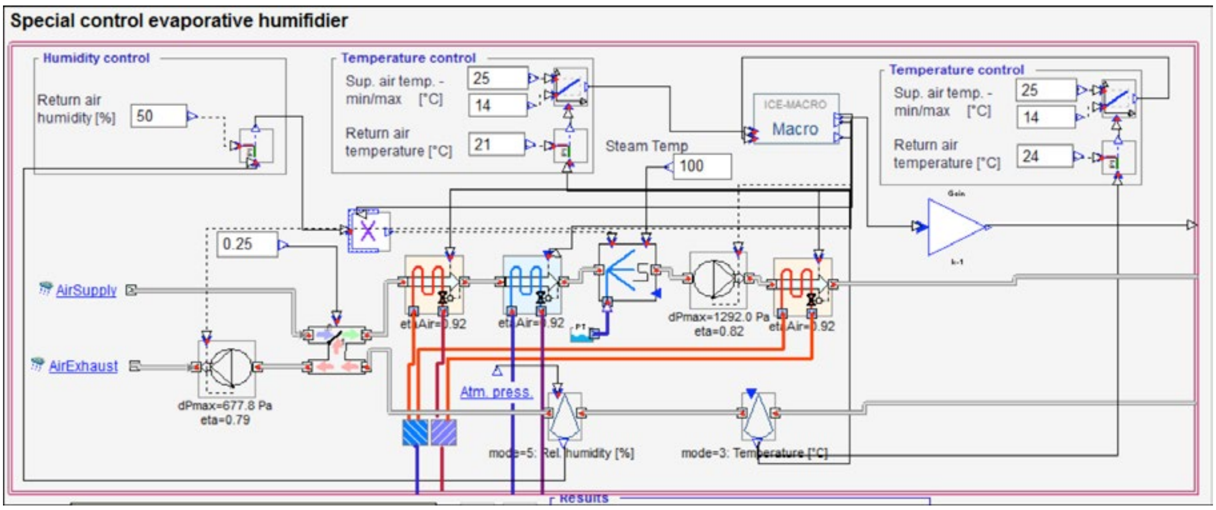


Figure 7. Modeling of the ventilation system

6_Building automation system

Computerized management systems are installed in the library of the various plants. Following the analysis of the protocols used (especially by the HVAC system), it was found that they were not well integrated and were not connected to the web. With the support of the European project's industrial partner Schneider Electric Company, TRIBUTE has designed the new architecture of control and management of energy systems of the building, trying to "catch up" as much as possible of existing systems while aiming at a target "high performance" of comfort and energy efficiency.
The building automation system of this first phase consists in summary:

- an automation server to control I/O modules, device management and monitoring on the fieldbus;
- Ethernet BACnet/IP-easy software;
- Ethernet gateway for existing HVAC system;
- a series of electricity and thermal energy.

In short you will install wireless facilities sensors (temperature, humidity and brightness) in any premises used by the public and will be done experimenting with CO_2 sensors and presence people in some quarters.
The goal is to capture data that are coming from both the existing temperature control system by new devices installed, process them critically and verify the correspondence with the energy simulation model created.

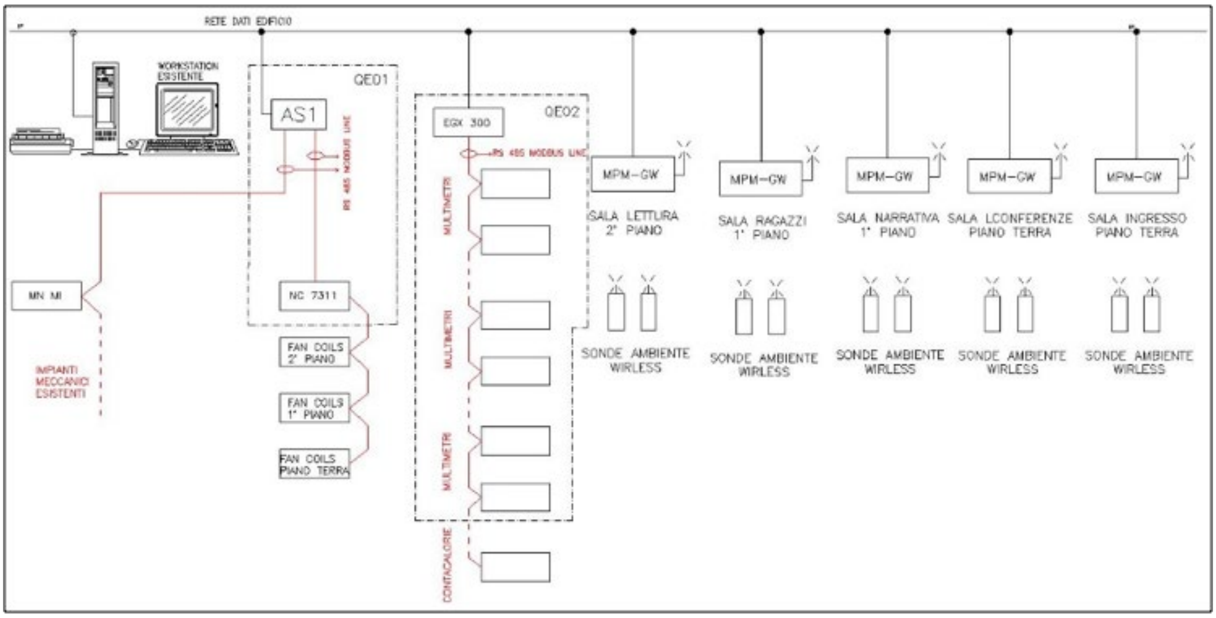


Figure 8. New BEMS

7_Conclusion and future developments

The adoption of an Energy Management System of an existing building (or complex of structures) needs to ensure better energy performance and comfort, deep diagnosis of building-system. Also, you should equip themselves with dynamic energy modelling system to analyze the state of fact and, following implementation of an appropriate system of building automation, to check for validity. Next, may be made before intervention, tested before, and after simulator with the feedback that comes from monitoring and measuring system installed. More details about the progress of the results can be found on the website of the project www.tribute TRIBUTE-fp7.eu/.

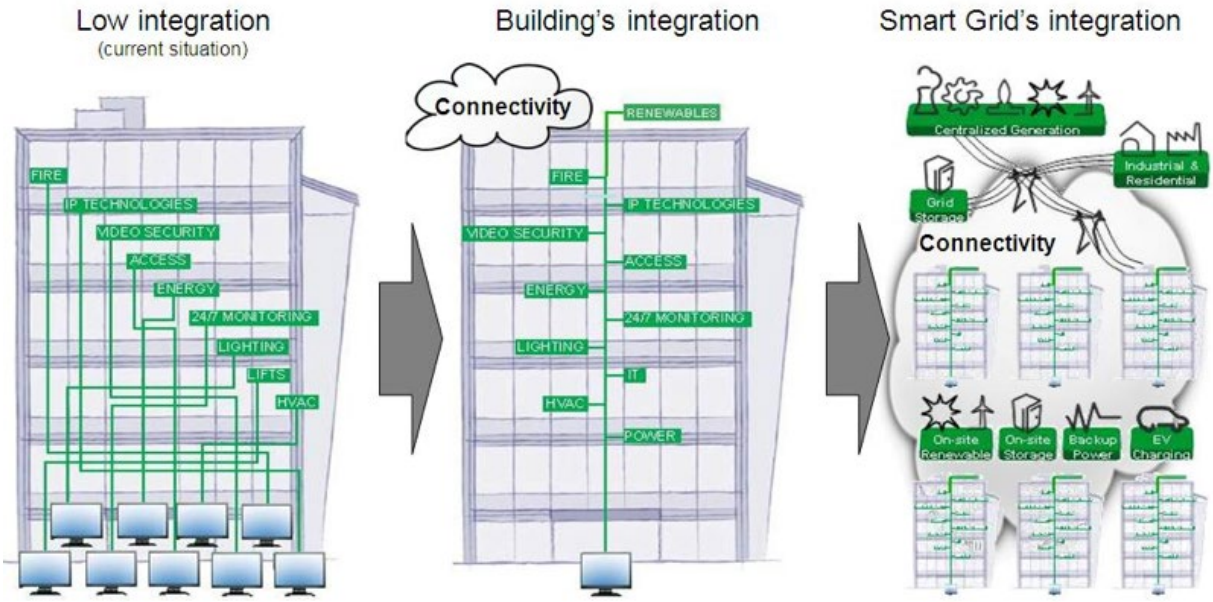


Figure 9. Smart Grid's integration

Furthermore, the results and knowledge from this case study, as those of other similar projects, are also intended to bring to a greater integration of smart grid and energy systems in buildings. The creation a replicable model from a case study to urban areas may: to generate an important economic value of the energy performance, to increase the comfort and safety of the occupants and to contribute to the reduction of greenhouse gases.

8_References

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European project PROBIS http://www.probisproject.eu/

European project TRIBUTE http://www.tribute TRIBUTE-fp7.eu/

Schneider Electric's Guide to using the UNI EN 15232

LEED Building Operations and Maintenance (O + M)

Abstract

There is a growing need for green energy nowadays, but this often clashes with limited space availability in buildings and several techno-economical constraints. An alternative approach based on integration and optimisation of different energy carriers can be undertaken. A feasibility analysis of Integrated Building Energy Systems (IBES) in non-residential buildings is carried out.
An IBES may represent a feasible way to go towards post-carbon cities and may be applied to different building types, making a low-carbon target profitable.
The model looks at generation, storage, heating and cooling technologies, in particular understanding the multi-carrier energy system interactions. The model seeks to optimise the choice of technologies and the dispatch of energy based on specific factors (costs or CO_2 emissions).
A newly constructed office building located in Los Angeles and London is modelled using the model DER-CAM. Various optimisation scenarios are run, looking at the impact that different cost-emissions weightings have on the performance of the IBES. The outputs show the investments required to implement the scenarios designed, the optimal dispatch of energy carriers and both the cost and emission savings this approach has created.
In comparison to the business-as-usual case, each optimisation scenario leads to emission savings. Systems' reliability has increased through reduced electricity purchase. Different results have been obtained in different cities, with higher cost savings in Los Angeles than in London. Thus, an IBES approach is more efficient in cities with warmer climates.

FEASIBILITY ANALYSIS OF AN INTEGRATED BUILDING ENERGY SYSTEM

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multi-carrier energy systems
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building energy integration

1_Summary

The interest in multi-carrier energy system concepts has been increasing in recent years, as reported in References. In particular, Andersson et al. (2007) have identified an energy hub concept that enables new design approaches for multiple energy carrier systems, highlighting the importance of a flexible combination of different energy carriers through conversion and storage technology in order to keep potential for various system improvements. Wasilewski (2013) has proposed a multicarrier smart energy delivery microsystem, modeled as SHEMS, focusing on the problems that have to be solved for operating an existing SHEMS structure, such as conversion and control issues. Rayati et al. (2015) have introduced "smart energy hub" as a new concept, proposing reinforcement learning algorithm as a practical method to find near optimal electricity and natural gas consumptions of this system. Shabanpour-Haghighi and Seifi (2015) have underlined the importance of performing multi-objective view in order to assess optimal operation of energy networks.
The final aim of this paper is the techno-economic analysis of a multi-carrier energy system in a building. For this purpose, an Integrated Building Energy System (IBES) is defined. Later, the proposed methodology for the IBES design is outlined. A model of the building is created through DER-CAM. Then, starting from a reference case and through the definition of an objective function, it is possible to plan both investments and electricity, heating and

cooling dispatch. Simulation inputs are collected, assumptions are made and restrictions are imposed to make every solution obtained from simulations feasible and physically acceptable. Finally, simulation output is analysed.

2_Integrated Building Energy System

An Integrated Building Energy System (IBES) includes technologies from some or all of the following components: Distributed Generation (DG), Combined Heat and Power (CHP), Distributed Storage (DS), Distributed Energy Management (DEM) and Heating and Cooling Technologies.

DG represents distributed electric power generators, either renewable or not. These units are often directly connected to the distribution network or to the customer side of the meter, and they are small in size compared to conventional power plants, not centrally dispatched nor planned. There could be wind turbines, gas and internal combustion engines (ICE), PV systems, fuel cells (FC), etc. Technology choice for installation may depend on maturity, space requirement, economic and technical assessment.

CHP systems are used widely at the customer level to enhance the efficiency of fuel use and to provide local power supply and income for operators, decreasing energy losses. They capture and use the by-product heat locally to provide domestic and industrial heating, providing energy-efficient power generation. They are one of the most promising Distributed Energy Resources (DER) for IBES applications. There are either electricity-driven or heating-driven CHP systems.

DS includes electric small-size storage devices such as batteries and electric vehicles (EV). It is mostly used in order to decrease disadvantages related to the intermittent nature of renewable energy generation sources, which has effects on the stability of the grid and availability of power.

DEM is defined as a set of measures, control systems and management methodologies and technologies applied to an IBES, leading to a more efficient use of the electricity system and reduced electricity-related costs, aiming at controlling locally DG, DS and load. DEM refers to energy efficiency measures, demand side response (DSR), which consists of several methods. Mostly, DEM systems are enabled by the availability of data coming from sensors and meters.

Several heating and cooling technologies can be utilized in an IBES. They are fundamental elements in order to achieve the interaction and optimisation of different energy carriers, as some of them, along with CHP systems, represent the link between electricity, heating and cooling. They include Solar Thermal, Heat Pumps, Hot Water Boilers, Heating, Ventilating, Air Conditioning & Refrigeration (HVAC&R) Systems, Electric Heating and Thermal Energy Storage systems.

The difference between the IBES concept and the microgrid one does not stand in its basic components, but in the way those are managed and they interact each other. There are various reasons leading to the shift to an IBES rather than the business-as-usual approach for electricity, heating and cooling load-meeting purposes. Some potential benefits resulting from an IBES approach are savings and possible additional revenues, along with significant social and environmental co-benefits resulting by an IBES deployment at scale, involving on-site generation and energy management measures. Decentralized generation, which incorporates multiple forms of energy into its core, leads to reduced electricity purchase and thus higher reliability of the energy system, peak load reduction and stronger independency from energy prices volatility. As an IBES relies on clean energy generation, or hybrid systems with low-carbon technologies, its diffusion can yield reduced impact on environment and air quality. Furthermore, deployment at scale of multi-carrier energy systems, including renewable energy resources such as PV systems and wind turbines, would easily help boosting technology maturity, making research and development for renewable energy (RE) resources easier. IBES-related benefits may be more important for fast-growing economies, which are involved into the implementation of several electrification projects as they are establishing their power networks, especially in rural areas.

3_Proposed Methodology for IBES Design

First of all, it is necessary to identify the typology of the analysed building and the year it was constructed in. It can be a newly constructed building or an existing one. If it already exists, input data are obtained through retrofitting. Different types of building and construction years lead to different energy requirements and load profiles, along with different available space for DERs installation, such as PV, solar thermal and engines. The definition of the building location is important as well in order to decide whether to take into account investments for a specific technology. In addition to this, the location is also related to weather data, which affect both load profiles and the power generation by solar PV and wind turbines.

Once both typology and location of the building are defined, the model has to be built. The first necessary step in order to build the model is setting load data, both for electricity (electricity-only, cooling and refrigeration loads) and natural gas (space-heating, water-heating and natural-gas-only loads) consumption. Hourly load profiles for week, weekend, and peak day-types per month are defined, for each of the load types included into the model. With regard to load data format, it is assumed that one daily load profile with hourly time steps coincides with the load profile for the entire month.

The second step, strongly related to the building location, is the definition of weather data. It consists of ambient hourly temperature for each month (°C) and hourly solar radiation for each month (kW/m^2), along with the hourly wind power potential (kW/unit).

The third step for building the model is linked to the CO_2 emissions and the utility tariffs, for both electricity and fuel. It is possible to define marginal CO_2 emissions (kgCO_2/kWh) and fuel CO_2 emissions rate, average kg of CO_2 released per kWh of energy content consumed in the combustion (LHV). Electricity rates and fuel prices, on the other hand, include fixed (monthly access fee) and variable charges (volumetric and power demand charges), which could be defined as Time-Of-Use rates, and need to be collected for the proper country and location considered. Financial incentives for the

development of renewable energy sources can be included into the model as well, such as feed-in tariffs (FIT) and net metering programs.
Techno-economical information about generation and storage technologies and infrastructures related to them, either already existing or that have to be installed, has to be included in the model. For each technology it is possible to model existing equipment and/or force equipment in the solution. Some evaluations must be done about excluding or forcing solutions into the optimisation output, as the availability of some generation and storage technologies may depend on the building typology, on its location and on the country the project is located in. Also costs and technological specifications may vary with the location.
Load management measures such as Load Shifting (LS), Demand Response (DR), and Direct Controllable Loads (DCL), along with Load Curtailment parameters, can be defined. However, applying load management measures is often difficult because of lack of information related to load curtailment costs for different building typologies, both for electricity and heating loads, although some interruption costs can be estimated.
After building the model of the energy system, it is necessary to define a reference case by taking into account the existing on-site technologies only (if any). The base case run allows applying an optimisation function to the model that is built. The simulation is realised through the model DER-CAM and could aim at minimising costs, CO_2 emissions or both of them through a weighted function.
The economic objective function is shown in (1):

$$\min C = \sum_i C_i \tag{1}$$

where C_i are different addend, each representing part of the total energy costs. They consist of facilities and customer charges, monthly power demand charges, time of use power demand charges, time of use energy charges inclusive of carbon taxation, costs of demand response measures and revenue from electricity sales. In addition, the objective function also considers on-site generation fuel and O&M costs, carbon taxation on on-site generation, and annualized technologies investment costs. Finally, natural gas used to meet heating loads directly incurs variable and fixed costs (inclusive of carbon taxation). This economic objective function is subjected to several constraints, related to generation and storage technologies, heat recovery, investments, electricity, heating and cooling supply.
For example, the electricity balance for each time interval is shown in (2):

$$CL_E - \sum CDRL_E + \sum \left(\frac{SI_E}{SCE_E} \right) = \sum Gen_E + URL + \sum (SO_E \bullet SDE_E) \tag{2}$$

where CL_E represents customer electric load, $CDRL_E$ represents customer electric load not met due to energy efficiency measures, SI_E and SO_E are electric storage charge and discharge power from EV and batteries, respectively, linked at charge efficiency SCE_E and at discharge efficiency SDE_E, Gen_E is electric power produced by generators to meet electricity-only end-use loads, URL is electricity purchased from distribution utility company.

The heat balance for each time interval is described in (3):

$$CL_H - \sum CDRL_H + \left(\frac{SI_H}{SCE_H}\right) + AL = \sum Gen_H + (SO_H \bullet SDE_H) + (\beta \bullet NGP) + \sum RECH \quad (3)$$

where CL_H represents customer heating load, $CDRL_H$ represents customer heating load not met due to energy efficiency measures, SI_H and SO_H are thermal storage charge and discharge heat, respectively, linked at charge efficiency SCE_H and at discharge efficiency SDE_H, AL represents the amount of heat used to drive absorption chillers, Gen_H is heating produced by generators, NGP is natural gas purchase, generated at efficiency β, RECH is the amount of useful heat recovered.

The weighted objective function for multi-objective optimisation purpose is shown in (4):

$$\min_f = WCost \bullet \left(\frac{TotalAnnualCost}{MaxCost}\right) + WCO_2 \bullet \left(\frac{TotalAnnualCost}{MaxCO_2}\right) \quad (4)$$

where MaxCost, which is the scaling factor for costs, is determined as the cost corresponding to a CO_2 minimisation run, while the weighting factor for CO_2, $MaxCO_2$, is the value of CO_2 emissions corresponding to a cost minimisation run. WCost and WCO_2 respectively are the weighted factors of the function, TotalAnnualCost represent the annual cost of the assessed optimisation scenario.

Different optimisation scenarios for the selected case study and model are then considered. The simulation output is composed of the dispatch of different energy carriers, investment decisions regarding onsite technologies and economic and environmental results. Economic and financial results are shown, in order to underline some important criteria in the project analysis, such as its NPV and its overall costs and revenues.

In order to tailor the procedure to the specific case, the optimisation run is suitably bounded by filtering DER and DS technologies according to specific availability and by ideating a resources installation strategy, according to available spaces, to be imposed into the tool.

The outlined dispatch strategy should undergo a Building Energy Management System, which actually supervises and controls the system state and the energy flow. Its function is to actually supervise and control the system state and, possibly, move the system away from the optimal dispatch strategy whether environmental conditions or technical feasibility evaluations do not allow following the optimisation output.

4_Case Studies

The model refers to an office building that is located in Los Angeles (USA, Case Study n. 1) and London (UK, Case Study n. 2). The office building is located in the city centre and it represents a non-residential case study. The building is newly constructed and it includes nine storeys above ground and three below, i.e. a lower ground floor and two basement floors. Its Gross Internal Area (GIA), measured to the internal face of the perimeter walls at each floor level, is 32,379 m^2. The maximum total building demand reaches 2,848 kVA, to which a future capacity allowance of 263 kVA is added. To this sum, a building diversity factor of 0.75 is applied. A maximum demand of 2,333 kVA follows those assumptions, and the incoming supply has to be 2,500 kVA. Assuming a 0.94 power factor, a maximum active power demand of 2,193 kW is considered. Consequently, this newly constructed building has an equivalent specific demand per GIA of 72 W/m^2.

For IBES purpose, roof and basement are the two key points in the building: here it is possible to install additional generation equipment, being the available physical space a fundamental constraint in this study. On the rooftop, 400 m^2 are available in order to install solar PV panels. The upper basement floor hosts a delivery office, storage rooms, loading bays, a cycle storage, recycling storage and a plant room, including chillers, main electrical room, risers and air handling plant room. Storage rooms could be used to locate IBES and to install different technologies, such as generators, turbines, heat pumps, and electrical and heating storage. The lower basement floor hosts a staff room, some offices and another plant room, including a generator room, fuel storage, chillers and boilers.

Modeling and simulation of the energy system are developed through DER-CAM. This is a mixed-integer linear model that allows finding out the global minimum to different optimisation problems.

Reference is a business-as-usual case, taking from utilities the whole amount of electricity and natural gas required for electricity, heating and cooling purposes and assuming that a central HVAC&R is available in order to meet cooling and heating loads. Later, cost-minimisation, CO_2-minimisation and multi-objective optimisation studies are carried out, through possible additional investments in IBES technologies.

Los Angeles load data profiles are obtained from DER-CAM database, based on ASHRAE climate zones. Similarly, London profiles are collected through ASHRAE climate zones-based assumptions and Seattle, WA weather data is used, as London is also located into ASHRAE climate zone 4. Annual electricity purchase is assumed to depend on the maximum power demand that results from the electric load profile. Annual natural gas purchase depends on typical natural gas consumption for similar buildings in the two locations.

Weather data are obtained from DER-CAM database, based on Typical Meteorological Year (TMY) data collections provided by the National Renewable Energy Laboratory (NREL), for Los Angeles, and taken from “Los Angeles International Airport” data included in TMY3. For the second case study, London Weather Centre weather data from 2003 included into CIBSE TM49 is used in this work.

Discrete and continuous energy production technologies are defined. The distinction is justified by the commercially available sizes of technologies and their economies of scale. Techno-economic characterisation of DERs is directly obtained by DER-CAM database for discrete technologies, while continuous technologies data is collected from several resources, as reported in References, and where it was not possible to find data assumptions are made. Marginal CO_2 emissions and fuel CO_2 emissions rate are taken from DER-CAM database, where data is obtained from Californian Independent System

Operator in combination with the U.S. Energy Information Administration. The same data is used for both case studies.
Electricity prices follow PG&E E-20 Secondary tariff for customers with maximum demands of 1,000 kW in Los Angeles, whereas they are derived from a similar building electricity bill for London case study. It is necessary also to tweak the model in order to include some UK tariffs that are not included in the tool, as it is designed for California-located projects. PG&E gas schedule G-NR2 are used for natural gas consumption in Los Angeles, while natural gas tariffs for London case study are obtained by npower.
PV FIT for both case studies, along with Renewable Heat Incentives (RHI) program for UK case study, are included in the model starting from DER-CAM optimisation results. It amounts to 0.065 $/kWh in U.S. and 9.98 p/kWh in UK, while RHI ASHP-related incentive is 2.54 p/kWh.
Only proper technologies that may be installed in a non-residential building located in the city centre have been analysed. A filter has been studied and applied, considering both tool limits and building constraints. ICE CHP units have been limited to small ones (75 and 250 kW). Large ICEs have been included in the set of inputs (1,000 and 2,500 kW) in order to have an electricity generation base and to allow CHP units to run and fully recover waste heat. In addition, FCs have been considered to allow having more low-emissions technologies among the potential installed DG sources. Furthermore, PV systems, EV charging stations, air source heat pumps (ASHP), lithium iron phosphate (LiFePO4) batteries and thermal energy storage (TES) systems can be installed. Other technologies have been excluded, such as wind turbines. Furthermore, capacity limits have been imposed, e.g. the space limit for TES. According to available space in the building basement, it is assumed to be 60 m^2, while a TES unit has a volume of 2.7475 m^3. As a 30 kWh/m^3 capacity is considered, a maximum number of 33 units can be installed, roughly providing 2,720 kWh heat storage. Similarly, a maximum batteries capacity of 1,080 kWh is imposed and only 300 kW FC are included.
The distribution in week and weekend days follows the 2015 calendar. Among weekdays, 3 peak days per month have been defined. The interest rate on investment is assumed to be 12%, as the investment in an IBES would be risky since it represents a new approach for energy supply of buildings.

5_Simulation and Results

Several optimisation studies are run for both locations and for different weights in the multi-objective function. An example of simulation output is given, while an overview is provided later in this paper.
Considering Los Angeles case study, a multi-objective optimisation, 50% cost – 50% CO_2 emissions, is shown. Costs and emissions resulting from this scenario, compared to the reference, are shown in table 1.

	Total Annual Energy Costs ($)	Total CO_2 Emissions (tons)
Reference	1,988,000	4,061.7
Investment Scenario	1,653,942	3,528.4
Total Savings (%)	16.8%	13%

Table 1. Costs and CO_2 emissions in 50-50 optimisation scenario – Los Angeles.

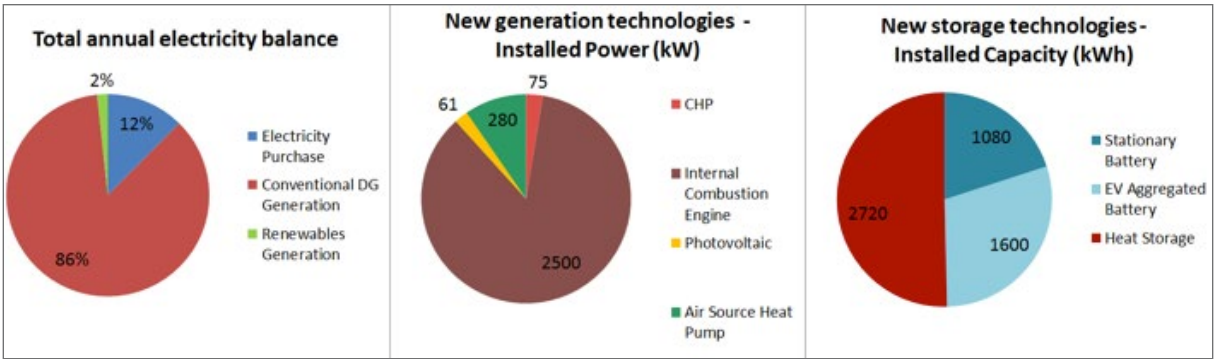


Figure 1. IBES technical details in 50-50 optimisation scenario – Los Angeles.

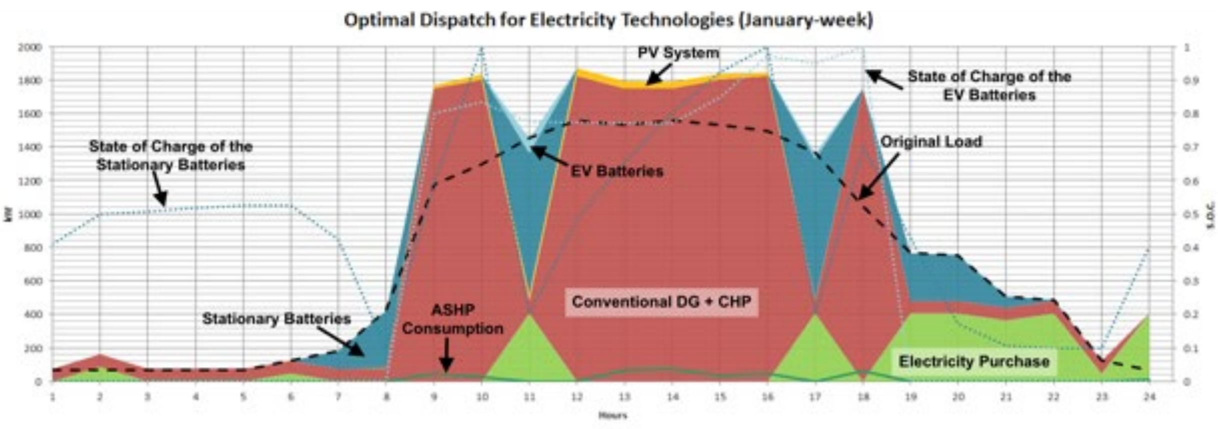
The IBES resulting from this optimisation scenario is shown in Figure 1. Two 1,000 kW internal combustion engines, a 75 kW CHP internal combustion engine, a 61 kW PV system, corresponding to the whole available PV area, and a 280 kW air source heat pump are the generation technologies involved in this investment scenario. In addition, stationary batteries with overall 1,080 kWh capacity, 1,600 kWh EV fleet and 2,720 kWh capacity of heat storage have been included. There is about 12% of electricity purchased from the utility. 131,667 kWh/year are generated by PV system, which allows accessing to the FIT.

Investments in new technologies are 5,554,114 $, It could be observed that the cost of the ICE is the 75% of the overall investment and that annualized costs are composed for their 54% by energy costs and OPEX.

Electricity dispatch in a weekday in January is shown in Figure 2. This dispatch strategy limits the use of the 2,500 kW ICE to central hours, when load is high enough. Purchasing electricity from the grid cannot be avoided, as there is no modularity of smaller ICEs, but a single larger engine only. During central hours, an example of PV, DS and load coupling is given. In the presence of PV and large ICE generation there has to be a higher load, thus DS and ASHP contribute by increasing it. Dually, batteries output helps providing electricity in intervals when load is too high to be met with a small CHP unit and too low for a large ICE.

Heating dispatch in a weekday in January is shown in Figure 3. ASHP runs during electricity-peak hours in order to increase electricity load. 75 kW CHP represents a base of heating supply during night-time, when electricity load is low enough to be supplied by CHP and utility. Excess heat output is stored in heat storage units, in order to cover almost the whole heating peak load and to contribute during night-time heat dispatch.

Figure 2. Example of electricity dispatch in 50-50 optimisation scenario – Los Angeles.



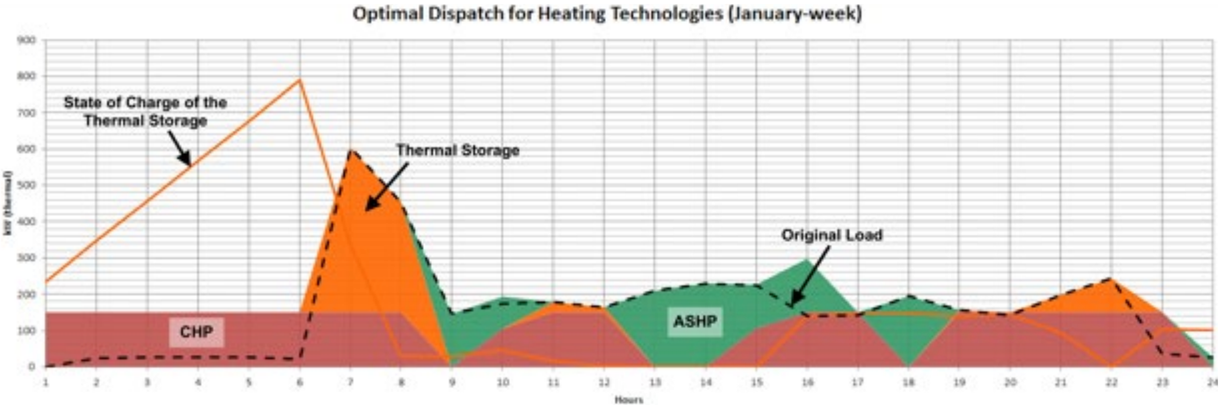


Figure 3. Example of heating dispatch in 50-50 optimisation scenario – Los Angeles.

Cooling loads are mainly fed by chillers for the entire year, and ASHP is exploited in some intervals only.

Economic analysis of this optimisation study is shown in Figure 4. Costs include initial investments in new technologies and investments in technologies whose lifetimes are less than 20 years. Yearly savings, including the PV FIT, amount to 1,122,459 $. Project's NPV is 2,588,179 $ and the payback period is 8 years, thus the project would be profitable.

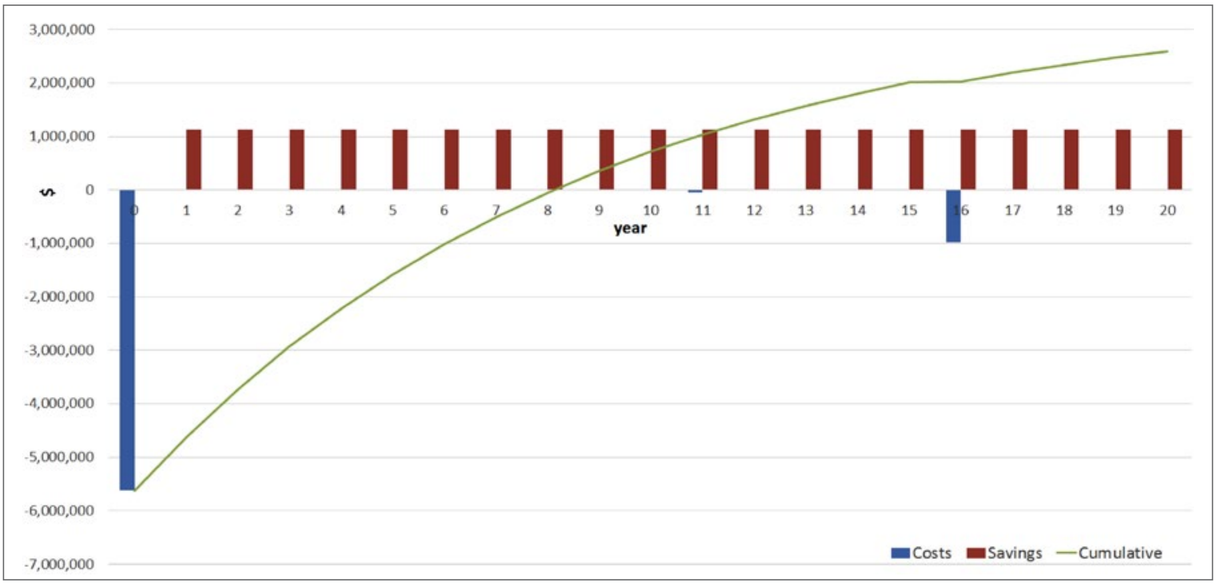
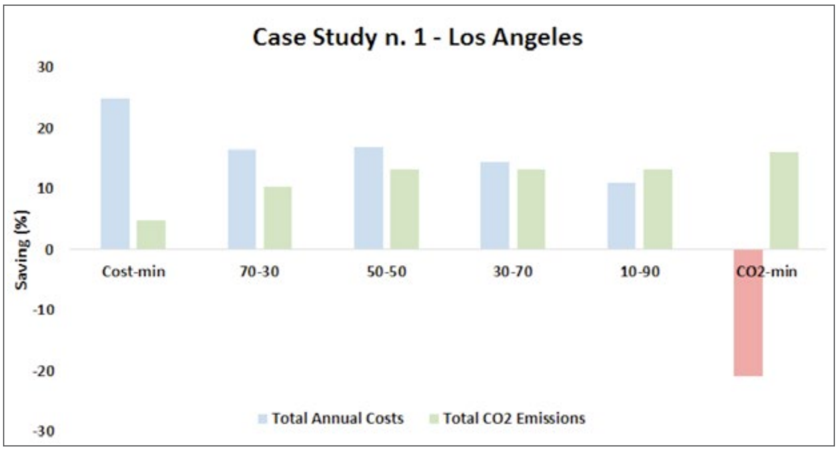
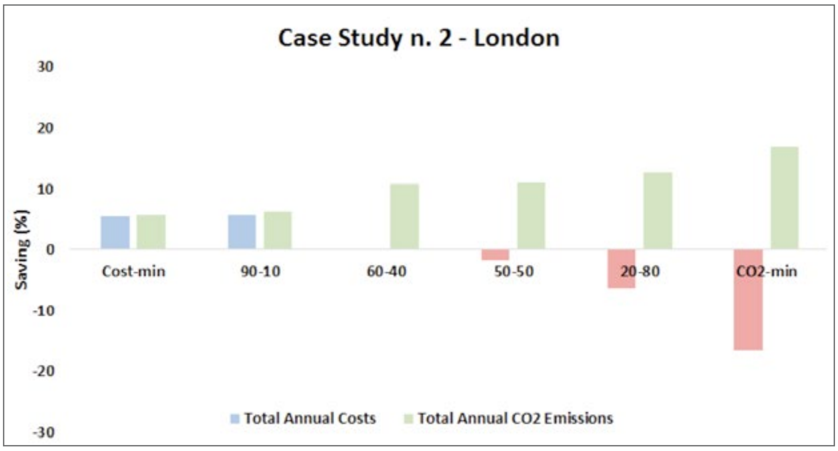


Figure 4. Economic analysis of 50-50 optimisation scenario – Los Angeles.

An overview of optimisation scenarios carried out in this paper is shown in Figure 5. The main similarity lies in the broadly technology choice the tool makes during the different scenarios of the optimisation analysis. This is true for the choice of installed technologies and dispatch strategies. Main differences between case studies are related to simulation outputs, electricity and gas purchase strategies and installed capacities in respective IBES. This is due to the higher impact of the IBES peak lowering on Los Angeles and to the shift from electricity to natural gas in order to meet electric loads and decreasing electricity purchase from the grid, which generates more savings in Los Angeles. Thus, an IBES approach is more efficient in cities with warmer climates, as it is easier to completely meet electric loads through a IBES rather than heating loads, due to technical, economic and space constraints. This economical result also depends on different utility tariff structures, as lowering electricity purchase peak brings higher savings in Los Angeles.

Figure 5. Optimisation scenarios comparison in the two case studies.





6_Discussion and Conclusions

A feasibility analysis of an Integrated Building Energy System in commercial buildings has been carried out, taking into account space and techno-economical constraints that an IBES would actually have to face, and looking for benefits resulting from the interaction between different energy carriers. A newly constructed office building in two different locations, Los Angeles and London, has been modelled, collecting several input data and filtering technologies that could be potentially installed. Various optimisation scenarios have been run in both locations, looking at the impact that different cost-emissions weightings had on the performance of the IBES. The outputs have shown the investments required to implement the scenarios designed, the optimal dispatch of energy carriers and both the cost and emission savings this approach has created.

In comparison to the business as usual case, each optimisation scenario has led to CO_2 emission savings, from a minimum of 5% in the Los Angeles cost-minimisation scenario to a maximum of 16.2% in the London CO_2-minimisation scenario. From an environmental point of view, plenty of solutions would produce bigger benefits than the business as usual scenario.

Every optimisation scenario has lead to net cost savings, but net costs increase when more ambitious CO_2 reduction targets are proposed, i.e. when the aim is to minimise the produced building carbon emissions. Redundancy increases annual costs because of investments in new expensive and

low-emissions technologies. However, the results do not take account of any CO_2 pricing policies, which depending on local policies could improve the financial performance of lower emission scenarios.
System reliability has heavily increased through an IBES approach, as electricity purchase has reduced, with almost a 100% reduction in some scenarios, like the cost-minimisation ones.
Internal combustion engines, coupled with a remarkable installed distributed storage capacity, result as the main DG technology, in order to integrate renewable energy resources and lower electricity purchase from the grid. As this leads to extremely increased natural gas consumption, attention must be paid in order to avoid creating a different fossil fuel dependency that could not be fulfilled.
Different results have been obtained in both cities, with higher cost savings in Los Angeles (24.7% in the cost-minimisation scenario) than in London (5.4%), mainly because of different electricity, heating and cooling loads. Thus, an IBES approach is more efficient in cities with warmer climates, as it is easier to completely meet electric loads through a IBES rather than heating loads, due to technical, economic and space constraints.
Obtaining input data has been challenging and time consuming. For example, it has been difficult to find any database or public information for the characterization of several technologies. Concerning London case study, input collection has even been more difficult, as tool's load and weather database is for US-located projects only. Obtaining real UK data has represented an important obstacle during the development of this work, and several assumptions have been made. For example, California grid marginal CO_2 emissions have been included in London model, though the generation mix in California is different from the UK one. Load data has been chosen following Seattle typical profiles because of climatic similarities, but this does not necessarily mean that demand profiles are similar, as building insulation standards and controls may differ. Creating a database that includes weather data and typical load profiles for different countries and building types, along with technologies characterization, would make modelling easier and would boost the development of an IBES approach.
A tool-related issue has been the impossibility to include some RE policies as an optimization input, such as UK's RHI program, and some utility tariff elements, such as UK's availability charge. It has been necessary to tweak the model in order to take into account actual constraints, e.g. including financial incentives in the optimisation output. Those amendments have cleaned model imperfections but they have affected the optimisation process, probably not leading to the absolute optimum. Although they have been considered in a post-optimisation analysis only, UK RE policies have had greater impact on the net cost savings, as RHI program involves ASHP, an important link between electricity and heating. This communicates how the development of renewable heating-related policies would help spreading a multi-carrier energy system approach.
Taking into consideration those evaluations, and supposing multi-carrier energy systems modelling easier to undertake in the future, IBES may represent a first feasible and profitable way to go towards post-carbon cities, and

may be applied to different building types, making a low-carbon target profitable. If IBES was deployed at scale, it could actually represent a remarkable step in the balancing of the energy trilemma, among energy security, environmental sustainability and energy equity.

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THE ROLE OF HOTELS IN SHAPING A SUSTAINABLE BUILT ENVIRONMENT

Abstract

Because of its function and nature, tourism sector has the potential to shape cities and citizens. The impact of tourism activities on global CO_2 is around 5% and its reduction is both a technically achievable and a socially beneficial target. For instance, in the hotel sector on one side the use of energy efficiency measures and renewable energy is far below its real potential; on the other side, due to the number of guests they host, hotels have the potential to act as an example of energy responsibility for other industries, as well as for individuals. At the European level, the issue of reducing hotels' energy consumption goes along with the aggressive goals set for the next decades for energy use reduction. In this framework, this paper presents the application of the Europe-wide known cost-optimal methodology to an existing hotel. Indeed, taking into account financial aspects is crucial for the market uptake of sustainable good practices in real, business-driven world. A small-medium mountain hotel located nearby Torino was selected as baseline model for the analysis and a number of energy efficiency measures were defined and implemented in a building energy simulation software. The obtained cost-optimal level of energy performance proved that proper combinations of existing technologies could lead to significant reduction of energy use. However, a critical discussion of the implemented methodology led to the proposal of different evaluation parameters for cost-optimal levels of energy performance for hotels, as a possible solution to catch stakeholders' interest toward green investments.

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1_Introduction

Tourism activities, mainly transportation and accommodation, contribute around 5% to global CO_2 emissions, of which 1% specifically related to hotel sector (UNWTO-UNEP, 2008). The relatively small footprint is nevertheless an issue that is being addressed by this major sub-sector of the tourism industry. In a world looking for new models of economic growth and development, adopting sustainable management practices is a condition for survival and success. Over the past several years, the world's leading hotel brands have increased their efforts to respond to environmental issues and invested significantly in going green (Kang et al. 2012). Sustainable practices are now pillars of the Corporate Social Responsibility (CSR) programs that the hospitality industry is increasingly implementing and being viewed as a green hotel is often a desired outcome of a hotel's CSR strategy (Gao and Mattila 2014). Indeed, today's customers are more and more sensitive to ecological matters and greening a hotel is inevitable not just to achieve operational cost savings, but also – and mainly – in order to meet hospitality customers' needs and boost their positive intention and behaviour toward the firm (Han and Kim 2010, Han et al. 2011). Moreover, by trying to answer to green costumers' needs, hotels have the potential to spread eco-friendly behaviours to a wider range of guests and to act as an example of energy responsibility for other industries (UNWTO 2011). Due to the number of clients they receive, they can become a channel for social change (Ryan 2002).

Despite these promising premises, at the current stage hotel sector's use of energy efficiency and renewable energy is far below its real potential and energy costs still represent a significant part of the operational costs of a tourist accommodation building (RELACS 2010). Particularly, dealing with the small-medium enterprises (SME) sector, poor energy performances are combined with hesitation in investing in green initiatives: even with the opportunities of business success and cost savings, SME hoteliers remain diffident, as they are not convinced of the financial benefits of such investments. Indeed the implementation of green practices requires significant initial investments, for which quantifying returns is often difficult, especially in terms of actual market appreciation (Kang et al. 2012).

In Europe the issue of reducing hotels' energy consumption goes along with the more general goal set by EBPD recast (European Commission 2010), envisaging that from 2021 all buildings newly built or undergoing major renovations will reach the nearly Zero Energy level. Based on the Directive formulation, nearly Zero Energy Buildings (nZEB) are buildings with a very high energy performance and where energy need is covered to a very significant extent by energy from renewable sources. It is task of each EU Member State to define figures for this generic definition, keeping in mind that "energy performance" is the calculated or measured amount of energy needed to meet the energy demand associated with the typical energy use of the building, which include energy use for heating, cooling, ventilation, hot water and lighting. In addition to nZEB policy, EPDB recast specifies that Member States shall set buildings minimum energy performance requirements in view to achieving cost optimal levels, which is the amount of primary energy leading to the minimum life cycle cost. While cost optimality is the current framework regarding the ambition level for renovation of existing buildings and new buildings, the principle of nearly zero-energy buildings will be guiding for new buildings as from 2021. Therefore it is important to secure a smooth and consistent transition of policies and markets from cost optimality to nearly zero-energy buildings (Kurnitski et al. 2011). For the purpose of both nZEB and cost-optimal level calculations, 9 buildings types to be considered are listed by the EPBD recast, including hotels.

In this framework, the IEE co-funded EU project "neZEH – nearly Zero Energy Hotels" (neZEH 2013a) has its place. This 3 years project aims at accelerating the refurbishment rate of existing buildings into nZEB in the hospitality sector and promoting front-runners, focusing on SME hotels. From the operational point of view, the project's scope consists of: providing technical advice to committed hotel owners; demonstrating the profitability, feasibility and sustainability of investments towards nearly Zero Energy through the application of deep retrofit measures to 14 hotels across Europe; promoting the 14 frontrunners; undertaking training and capacity building activities. Reaching these goals set up a number of theoretical issues: indeed, the nearly Zero Energy level, as well as the cost-optimal level of energy performance for hotels, is not put into figures in most of Member States and the typical energy use for this building type is not defined. Following EPBD precepts in terms of energy uses, in a neZEH the typical energy use in hotels can be identified as the energy used for "hosting functions", as proposed by Buso et al. (2014). While different hotels may offer different facilities, entailing a wide gap in the energy needs among buildings with the same general use classification, hosting functions, mainly related to guestrooms, are always present and their energy uses aim at providing comfort conditions to guests and workers. This approach was followed by the neZEH project for setting preliminary benchmark values for hosting functions for new and retrofitted neZEHs in the project partner Member States (neZEH 2013b). Figures regarding primary energy (PE) use for heating, hot water, cooling, lighting and appliances, are shown in Table 1 and were identified as a result of national legislations and literature review.

neZEH partner	Croatia	France	Greece	Italy	Romania	Spain	Sweden
PE indicator - New [kWh/m²y]	77	115	76	71	80	72	134
PE indicator - Refurbished kWh/m²y]	100	150	99	92	104	94	174

Table 1. neZEH benchmarks for hosting functions for new and retrofitted hotels in project partner countries.

Given a general overview, this research aims at presenting and discussing the results of applying the EPBD recast-prescribed cost-optimal methodology to an Italian existing hotel and to verify whether the neZEH benchmarks are achievable and financially convenient. Energy efficiency measures (EEMs) are applied to the selected hotel and their impact on energy consumption and global cost is evaluated. The analysis aims at finding the cost-optimal EEMs and the cost-optimal level of energy performance, considered as a step toward the nearly Zero Energy Hotel target. The obtained results are then critically discussed, particularly questioning whether cost-optimal methodology can give actual support to define the best retrofit strategies for hotels and can seize the extra-benefits (e.g. market appreciation) that going green entails for this kind of business.

2_Method

In this section the steps undertaken in the present cost-optimal methodology exercise, here listed, are extensively described: (1) description of the baseline hotel building; (2) definition of technically feasible EEMs - single measures and packages of measures; (3) energy evaluation through simulations; (4) economic evaluation of the baseline model and the packages of measures.

2.1_Baseline building

A small-medium mountain hotel located in Piedmont (North of Italy) was selected as the baseline model for the cost-optimal analysis. This existing building, built in 1929, was converted into a hotel in the 80's. In 1998 partial retrofit measures, such as boilers replacement, were undertaken. It is a seven-storey building (2 basement levels and 5 floors) in which the following functions are located: the lower level basement houses unconditioned technical rooms and deposits and conditioned function-rooms; the upper basement level hosts laboratories and entertainment areas; the ground floor has a hall, offices and food services (kitchen, restaurant and cafè); the upper floors house 73 guest rooms, with 170 beds in total. The building longitudinal axis is in West-East direction and guestrooms are mainly South oriented, as shown in Figure 1. Coming to figures, total net conditioned area and volume are respectively 5.858 m^2 and 22.669 m^3, the aspect ratio is 0,51 m^{-1} and the floors dimensions vary from 80x18 m to 80x12 m.

Figure 1. Typical floor plan of the selected existing hotel.

Building plants consist of three gas boilers of 500 kW each, serving the heating system for ground and upper floors with radiators and fan coils as heating terminals, the Domestic Hot Water (DHW) production and three Air Handling Units (AHU) for the climatization of the basement, rarely in use. Finally, envelope thermal properties are summarized in Table 2, in comparison with Italian minimum requirements given by D.L.311/2006 (Italy 2006).

Table 2. Envelope thermal properties of the baseline model.

	Baseline Building U [W/m^{2}K]	Standard Requirements U [W/m^{2}K]
External wall	1,09	0,33
Roof	0,97	0,29
Windows	1,95	2,00

2.2_Energy Efficiency Measures (EEMs)

Technically feasible retrofit possibilities of the baseline model were defined in order to achieve energy savings through the improvement of the building envelope properties and of the building systems efficiency and through the exploitation of Renewable Energy Sources (RES). As recommended by the European Commission (2012), single EEMs were combined in packages in order to investigate possible synergy effects. Table 3 lists the single Energy Efficiency Measures and in Table 4 the 13 resulting packages of measures are presented.

Table 3. Single Energy Efficiency Measures (EEMs) applied to the baseline model.

EEMs type	Code	Intervention	U [W/m^{2}K]
Envelope	EEM1	External walls insulation (from internal side)	0,32
	EEM2	Walls to unheated insulation	0,32
	EEM3	Roof insulation (from internal side)	0,24
	EEM4	Windows substitution	0,90
Plants	EEM5	Substitution of gas boilers with condensing boilers	
	EEM6	Substitution of heating terminals with radiant ceiling	
	EEM7	Installation of mechanical ventilation system	
RES	EEM8	Installation of Solar Thermal (ST) Panels (255 m^2, 100% DHW need)	
	EEM9	Installation of Solar Photovoltaic (PV) Panels (153 m^2, 19 kWp)	

Code	Intervention
P1	EEM1 + EEM2 + EEM3 + EEM5
P2	EEM1 + EEM2 + EEM3 + EEM5 + EEM6
P3	EEM1 + EEM2 + EEM3 + EEM4
P4	EEM1 + EEM2 + EEM3 + EEM4 + EEM5
P5	EEM1 + EEM2 + EEM3 + EEM4 + EEM5 + EEM6
P6	EEM1 + EEM2 + EEM3 + EEM5 + EEM8
P7	EEM1 + EEM2 + EEM3 + EEM5 + EEM6 + EEM8
P8	EEM1 + EEM2 + EEM3 + EEM7 + EEM9
P9	EEM1 + EEM2 + EEM3 + EEM5 + EEM7 + EEM9
P10	EEM1 + EEM2 + EEM3 + EEM5 + EEM8 + EEM9
P11	EEM1 + EEM2 + EEM3 + EEM4 + EEM5 + EEM8
P12	EEM1 + EEM2 + EEM3 + EEM4 + EEM7
P13	EEM5 + EEM8

Table 4. Packages of EEMs applied to the baseline model.

2.3_Energy Evaluation

The energy performances under investigation are those prescribed by the Italian D.Lgs 192/2005. It transposes the EPBD (European Commission, 2002) to the Italian context and requires to calculate the amount of primary energy necessary for maintaining the whole building at the standard comfort condition during the heating season (i.e. t_{indoor}=20°C). Building configurations were modeled in Docet energy simulation software. The Docet version used was based on the Italian standard UNI/TS 11300 1-2 (CTI 2012, 2008) simplified calculation method. Developed by the national research institutions ITC-CNR and ENEA, it was expressly intended to easily provide Primary Energy (EP_{gl}) values to be used in the Italian Energy Performance Certificates (EPCs). At the time of this research, the Italian EP_{gl} only took into account energy uses for heating and DHW, therefore Docet software only provided information about the delivered energy and primary energy used for these functions (electricity uses for lighting, appliances and cooling are not simulated).
Italian regulation for minimum primary energy requirements and EPCs was updated in October 2015. Now EPCs have to rate, for non-residential buildings, energy uses for lighting, cooling and elevators for all non-residential buildings.

2.4_Economic Evaluation

Aim of the present work is to define the cost-optimal level of energy performance for an existing hotel building. In accordance with EPBD recast, the cost-optimal framework methodology is based on a comparative methodology framework that builds on the global cost (C_G), or net present value, method. Input data for global cost calculation are shown in formula 1:

$$C_G(\tau) = C_I + \Sigma_J * \left[\Sigma_{I=1}^{\tau} \left(C_{a,i}(j) * R_d(i) \right) - V_{f,\tau}(j) \right], \quad (1)$$

where $C_G(\tau)$ represents the global cost referred to starting year τ_0, C_I is the initial investment cost, $C_{a,i}$ (j) is the annual cost for component j at the year i (including running costs and periodic or replacement costs), R_d (i) is the discount rate for year i, $V_{f,\tau}$ (j) is the final value of component j at the end of the calculation period (referred to year τ_0). The discount rate R_d is used to refer the costs to the starting year; it is expressed in real terms, hence excluding inflation.

For the baseline model and for each model implementing EEMs all the data were defined and the global cost was calculated. The calculation period was set as 30 years; 4% discount rate was used; investment costs were taken from Piedmont Price List 2011 (Regione Piemonte 2011); replacement and maintenance costs were derived from EN 15459:2007 Appendix A (CEN 2007); energy costs were calculated by applying to Docet simulation results the following energy tariffs: natural gas cost = 0,091 €/kWh; electricity cost = 0,2 €/kWh.

3_Results

3.1_Energy Evaluation

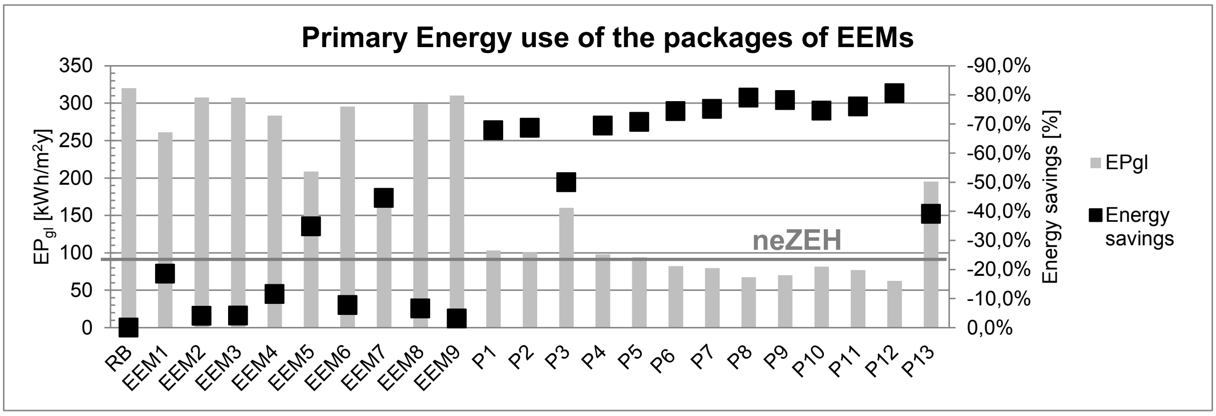
As a first step, the theoretical delivered and primary energy uses of the baseline model were defined through simulation. Results, presented in Table 5, show the building energy performance related to the typical energy use of the building for heating and DHW production.

Table 5. Simulated delivered and primary energy use of the baseline model.

Energy source	Energy use	Delivered energy [kWh/m²]	Primary energy [kWh/m²]
Gas	Heating	298,8	299,3
Electricity		0,2	
Gas	DHW	20,9	20,9
EP_{gl}			320,2

By applying the defined EEMs and packages of EEMs to the RB, the achievable energy savings are obtained. In Figure 2 the primary energy needs of the several design options are shown in parallel with the related energy savings and with the neZEH benchmark for retrofitted hotels. As expected, single energy efficiency measures were less effective in reducing the building energy use than packages of measures, in which superposition of effects and synergies allowed to reach savings always higher than 40%. The most efficient EEMs (savings > 30%) are related to the plant system (EEM7 and EEM5). Regarding EEM9, PV panels installation, the evaluated savings are the lowest because of the energy uses taken into account in the simulation (no electricity): positive effects of PV panels can be seen in packages where they are coupled with the mechanical ventilation system (P5, P6). It is also worth noting that 7 packages of measures gave primary energy results lower than

Figure 2. Primary energy use for heating and DHW of the simulated models implementing EEMs and packages of EEMs.

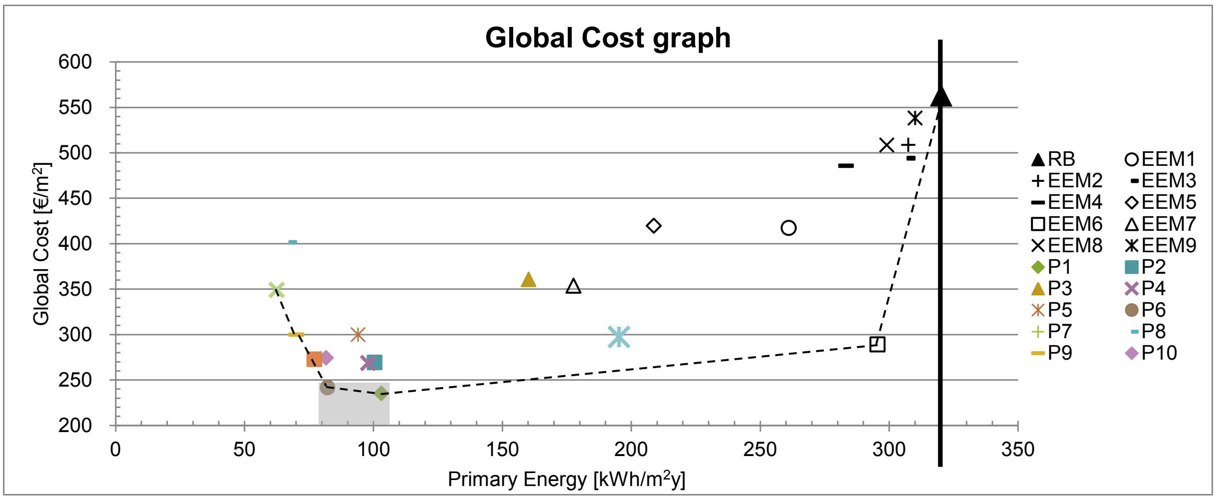


Italian neZEH benchmark (< 92 kWh/m²y). The highest energy savings (81%, EP_{gl} = 63 kWh/m²y) were obtained by P12, where heat losses are minimized by insulated envelope and windows and ventilation losses are reduced thanks to the mechanical ventilation system. However, neZEH benchmarks consider all energy flows in the primary energy indicator, while the Italian regulation only takes into account energy for heating and DHW production. Therefore, the neZEH benchmark will not be considered in the cost-optimal graph.

3.2_Economic Evaluation

The performed energy analysis was functional to the definition of the cost-optimal level of energy performance of the selected hotel building. Primary energy results for EEMs and packages of measures were plotted versus the calculated global costs, as shown in Figure 3. In the graph, the black vertical line represents the EP_{gl} of the reference building, the dotted black line draws the cost curve and the grey area highlights the cost-optimal level of energy performance, i.e. the primary energy use of the EEMs that minimize the global cost. Results in Figure 3 highlight that the cost-optimal level for the selected building is reached by 2 options. The lowest global cost is obtained by P1 (235 €/m² and 103 kWh/m²y), implementing to the baseline model opaque envelope thermal insulation and new condensing boilers. P6, where ST panels are added to the features of P1, provides better energy performance (82 kWh/m²y) for a slightly higher global cost (242 €/m²). The graph also provides a rationale for defining the best intervention to invest in. On one hand, packages with similar EP_{gl} may have different global cost (C_G), as exemplified for instance by EMM6 (EP_{gl} = 296 kWh/m²y; C_G = 289 €/m²) and EEM8 (EP_{gl} = 299 kWh/m²y; C_G = 508 €/m²). On the other hand, packages with very similar global cost can differ in energy performances. P5 (EP_{gl} = 94 kWh/m²y; C_G = 300 €/m²) and P13 (EP_{gl} = 195 kWh/m²y; C_G = 297 €/m²) are an example.

Figure 3. Global Costs of the EEMs and packages of EEMs represented as a function of primary energy consumption.



4_Discussion

A cost-optimal exercise was performed for an Italian hotel building in order to test the applicability of general EU disposition regarding nZEB and cost-optimality in a national context and to a specific building type. Results presented above are here interpreted and discussed.

The energy-related outcomes seem to confirm that, also in the case of hotels, current technologies related to energy savings, energy efficiency and renewable energies are sufficient to reach, in combination, a suitable target for nearly zero-energy buildings (Ecofys et al. 2013). Nevertheless sound evidences of this statement cannot be presented because of the discrepancy between the energy flows included in primary energy calculation in the neZEH project benchmarks and those considered in the Italian EP_{gl}. This mismatch leads to consider, in the Italian application of neZEH benchmarks, only a fraction of the typical energy use of the building. The issue here raised is consistent with the problem of heterogeneous definitions of nZEB implemented at the national level reported by Jurnitski et al. (2014) and may be partly solved by the new Italian dispositions regarding minimum energy requirements and energy performance certificates. Next steps of the present study should update the method presented in section 2.3 Energy Evaluation.

Another aspect asking for further investigation is whether the typical primary energy use of the building is the proper parameter to be taken into account for energy and cost-optimal evaluation for hotels, and for multipurpose buildings in general. In hotels the energy use for maintaining occupants' comfort is complementary to energy uses for maintaining the quality of offered services. Indeed, for each multipurpose building use, offered services are the characterizing element and their energy consumption is very dependent on the service quality, which in turn is proportional to the economic advantages deriving from them. Therefore, from the private investors' standpoint, the whole (typical + extra) building energy use may be considered when economic evaluations of different retrofit design options are compared.

Dealing with the economic evaluation of buildings retrofit, the cost-optimal methodology, used at national level to define the most economically sustainable minimum energy requirements, may not be satisfactory for the private investors' perspective. At the current stage, only reduced running cost and higher final value of the building are considered as assets for implementing retrofit measure. For boosting green private investments, extra benefits deriving from the renovation process, such as improved image of the building, new market positioning, increased guests comfort and satisfaction, should be included, with appropriate indicators, in the calculation method. Examples of studies addressing the link between green investments and the quantification of not straight tangible returns flourish in the hotel sector, where, for instances, guests' willingness to pay for sustainable lodging has been deeply investigated (Han et al. 2009, Kang et al. 2012). In hotel buildings, the impact of benefits on the hoteliers' finances comes from workers and guests' satisfaction and from the building performances, tackling all at once comfort, health, market appreciation and residual value issues.

5_Conclusions

The cost-optimal analysis applied to an Italian existing hotel pointed out that packages of energy efficiency measures have the potential to lead to the energy performance requirements proposed for nearly Zero Energy Hotels and that cost-optimal level of energy performance is able to significantly reduce the building primary energy use (-74%). These findings were critically discussed in view of reaching a realistic and effective energy and economic evaluation for hotel building type: alternatives to the energy use prescribed for calculations by the EPBD recast and to the variables to be included as co-benefits in the global cost methodology were introduced.

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Special Session
ODYSSEUS project results

LINKED ENERGY DATA, ENABLING MONITORING AND DECISION SUPPORT FOR IMPROVED ENERGY MANAGEMENT

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Abstract

This paper shows how the European Odysseus project (1) reduces (non-renewable) energy/CO_2 by improved decision making based on multi-level, semantic energy configuration / monitoring data, fully based on open standards – W3C Linked Data approach/Semantic Web technology (2) – and an open source semantic server – Apache Marmotta (3) – implementing those open standards.

1_The European Odysseus Project

Odysseus stands for Open Dynamic System for Saving Energy in Urban Spaces, an ongoing European FP7 project in the scope of "Energy-positive Neighbourhoods". The project coordinator TNO, the largest Dutch R&D institute, is also leading the energy modelling aspects complemented by the domain modelling by partner PRIVA, the leading Dutch energy solution provider for green houses and the built environment. CSTB, a French R&D institute is responsible for the software implementations, cGS, a Spanish IT consultant/developer and Advanticsys an expert in monitoring systems. Dissemination is managed by the Italian ESoCE Net and pilots are performed for the cities of Manchester and Rome.
Main goal of the project is ("bad" or non-renewable) energy/CO_2 reduction via awareness/monitoring and tactical/operational decision support that is economically feasible and not compromising peoples functions and comfort levels, in short: a sustainable solution (figure 1).

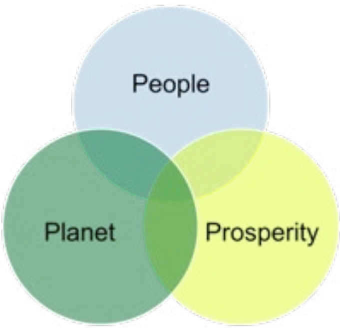

Figure 1. Sustainable solutions.

Reducing energy consumption can be typically accomplished via (in that order) (figure 2):

- Reduction of energy demand
- Use of renewable energy resources, and
- Improvement of energy efficiency

Figure 2. Measure types to reduce energy.

Odysseus focusses on the third bullet especially via improved decision making in the design and operational phases on Neighbourhood, Entity/Building and Device level (figure 3).

The three levels addressed implicate we have to deal with a variety of existing ICT worlds including:

- GIS – Geo-spatial Information Systems
- BIM – Building Information Modelling, and
- BAS – Building Automation Systems, sensors, meters measuring conditions and (energy) flows

	LifeCycle / Supply Chain	Program	Design	Build	Operate
GIS	Neighbourhood (Urban Areas)				Odysseus
BIM	Entities (Including 'Buildings')				
BAS	Devices				

Figure 3. Life-Cycle and Supply-Chain scope.

In this paper we focus on the open, semantic modelling of those three levels in an ontology referred to as dEPC – dynamic Energy Profile Card.

2_Modelling Approach

2.1_Introduction

This chapter describes a Modelling Guide (MG) for the development/definition of ontologies, sometimes also referred to as "object libraries". These ontologies are making use of a predefined "Concept Modelling Ontology" (CMO) generic upper ontology containing key modelling constructs for product modelling in general that are not yet part of the standard languages we use (OWL2, RDFS, RDF). CMO is a shared development by TNO (NL), CSTB (F) and RDF (BG).

2.2_Design & Implementation Principles

- Maximize reuse of existing open 'semantic web' standards (OWL2, RDFS, RDF, SPARQL, Turtle)
- Minimize own particular restrictions, extensions and modelling rules for maximum reuse
- Keep everything as simple as possible (but not too simple)
- Stick fully to the assumptions by the 'semantic web':
  - Open World Assumption (OWA): all OWL ontologies follow the Open World Assumption: all things not asserted are unknown (not false).
  - No (one) Globally Unique IDentifier (GUID) assumption. All identifiers (IDs) for OWL primitives (classes, properties, individuals) are never assumed to be Globally Unique for those primitives. They can be unique names in themselves but one primitive might have more than one such identifier. OWL provides modelling primitives to state explicitly whether identifiers refer to the same or another resource (owl:equivalentClass, owl:equivalentProperty and owl:sameAs).

The set of extra modelling primitives is modelled as a generic 'upper ontology' called CMO distributed as a Turtle file: cmo.ttl. This ontology can be imported and reused by any other end-user ontology. The used prefix is "cmo". The CMO ontology itself is available at:

- http://www.modelservers.org/public/ontologies/cmo/cmo.ttl

The project specific ontologies (and data) using CMO are available at:

- http://www.modelservers.org/public/ontologies/odysseus (including HTML variants for information).

All relevant ontologies and data sets are available for SPARQL querying at:

- http://marmotta.tno.nl:8080/marmotta

2.3_Definitions

Ontology & Hierarchy

An ontology is an abstract, simplified view of a part of reality to be represented for some purpose. An ontology is essentially a set of Concepts, Properties and Relationships, or in OWL-terminology: a set of Classes, Datatype Properties

and Object Properties respectively. Furthermore it contains Datatypes and all kinds of Restrictions (cardinality restrictions, universal and/or existential (owl:allValuesFrom / owl:someValuesFrom) logical restrictions, owl:hasValue restrictions, rdfs:domain and rdfs:range restrictions for properties etc.).
A hierarchy is a set of Classes or Properties connected by a specific Object Property that constitutes a partial or complete order between those classes. Such object property can be used to say that one class is 'higher/lower' than another class. Note: a hierarchy is not necessarily having a tree-structure: one higher class might be associated to 0, 1 or more 'lower' classes and one lower class might be associated to 0, 1, or more 'higher' classes. Often the interest goes to a hierarchy that constitutes a complete order: all classes of an ontology are part of the hierarchy, there are no "hanging classes", classes which have no higher/lower link with other classes.

Taxonomy & Meronomy

A taxonomy is a special kind of hierarchy where the object property connecting the classes is 'rdfs:subClassOf' with top-level class "owl:Thing" (the predefined 'most generic' class).
Another hierarchy example, not directly supported by OWL is a Meronomy where the object property connecting the classes is 'typicalPart'. In general the focus will be in the first place on taxonomies but meronomies are made possible via restrictions where all, in some way restricted properties are interpreted as "typical". In case of optional properties/parts, explicitly modelling minCard=0 (which implicitly is the default already) for a property, marks it as a qualified hasPart property. 'Typical' doesn't say anything about necessity! This approach is introduced because in OWL anything can be a part of anything else (when not constrained explicitly). Sometimes however, it is handy to make this (optional) relevance explicit so that the end-user can be given a template involving typical/relevant parts for an individual of certain class.
A taxonomy or meronomy or both typically form(s) the "backbone" of an ontology.

Decomposition

Explicit decomposition will only be applied on individual level by providing a predefined hasPart object property on class-level. As stated before, typical decomposition will be handled via qualified restrictions on this hasPart object property.

2.4_Main Modelling Guidelines

Language

The language chosen to define ontologies is: OWL 2.
Authoritative reference:
OWL 2 Web Ontology Language Primer (Second Edition), W3C Recommendation 11 December 2012, http://www.w3.org/TR/owl2-overview/.

Since we do not want to restrict ourselves w.r.t. expressivity we allow the "OWL 2 Full profile" to be used, knowing the consequences w.r.t. computational complexity and the limited support by reasoners.

OWL uses constructs from RDF Schema and RDF:

- Authoritative references: RDF Schema 1.1, W3C Recommendation 25 February 2014, http://www.w3.org/TR/rdf-schema/.
- RDF 1.1 Concepts and Abstract Syntax, W3C Recommendation 25 February 2014, http://www.w3.org/TR/2014/REC-rdf11-concepts-20140225/Overview.html.

Syntax

The syntax form ("format" or "serialization") chosen in is: Turtle.
Authoritative reference:

- RDF 1.1 Turtle, Terse RDF Triple Language, W3C Recommendation 25 February 2014, http://www.w3.org/TR/turtle/.

Direct access

Beside import/export (aka upload/download) of Turtle files we assume direct access via the SPARQL query language.
Authoritative reference:

- SPARQL 1.1 Overview, W3C Recommendation 21 March 2013.

Natural correspondence ('interpretation of OWL meta-concepts')

- Concepts are modelled as OWL Classes
- Datatypes are modelled as OWL Datatypes (reusing underlying XSD Datatypes)
- Attributes are modelled as OWL Datatype Properties
  - In complex cases where "values" are really not sufficient one can always consider a complex property as a Concept and hence represent it as a Class (think material properties)
  - Some predefined attributes reflecting quantities: base quantities like length and time but also derived quantities like velocity, timesPerYear etc.
- Relationships are modelled as OWL Object Properties
  - One predefined relationship: hasPart
- Constraints are modelled as OWL Restrictions

Class/property naming conventions

- A class name always starts with a capital (upper case) letter ("CamelCase")
- A property name always starts with a non-capital (lower case) letter ("camelCase")
- Class and property names are in English.
- Classes and properties can have multi-lingual labels using rdfs:label
- In case of multiple labels in the same language skos:prefLabel can be used in case one wants to visualize the taxonomies in multiple languages , the preferred labels are then the 'determined choice' for the tree-node names per language.
- Character names according to RDF1.1 Turtle production rules (UTF-8)
- Class and property names are singular.

EXAMPLE

```
:Tunnel
  rdf:type owl:Class ;
     rdfs:subClassOf :CivilInfraArtefact .
```

We can also subclass while giving the exact discriminating property value (Dutch example):

```
:terrainType
  rdf:type    owl:DatatypeProperty ;
     rdfs:range  [ a rdfs:Datatype ;
         owl:oneOf  ( "ground"^^xsd:string "water"^^xsd:string )] .
:Bridge rdf:type owl:Class ;
     rdfs:subClassOf  :SpanStructure ;
     rdfs:subClassOf  [ a owl:Restriction ;
          owl:hasValue    "water"^^xsd:string ;
          owl:onProperty  :terrainType] .
```

It is also possible to use 'range-like' discriminators (not just specific values):

```
:CheapTunnel rdf:type owl:Class ;
  rdfs:subClassOf  :Tunnel ;
  rdfs:subClassOf  [ a owl:Restriction ;
     owl:allValuesFrom  [ a rdfs:Datatype ;
     owl:onDatatype xsd:float ;
     owl:withRestrictions  ( [ xsd:maxExclusive "6000000"^^xsd:float ] )] ;
     owl:onProperty    :cost] .
```

Individual decomposition

We predefine an instance decomposition object property:

```
:hasPart
  rdf:type owl:ObjectProperty .
```

This property is not transitive! It defines the direct parts of a whole. The transitive variant can be easily defined and derived/inferred if needed. We choose the direct variant for not "counting double" when traversing all parts of a whole in total cost, total energy etc. calculations.

EXAMPLE

```
:Deck_1
  rdf:type :Deck .
:Bridge_1
  rdf:type :Bridge ;
  cmo:hasPart :Deck_1 .
```

Typical decomposition

As stated earlier, typical decomposition is modelled at classes via restrictions on the hasPart object property in a qualified way. The interpretation is that any property restricted in some way (min/max cardinality, allValuesFrom, someValuesFrom, hasValue…) is by definition relevant for the class hence a "typical" property. For optional properties without constraints we explicitly model explicitly "minCard=0" to indicate this fact.

EXAMPLE

```
:Bridge rdf:type owl:Class ;
  rdfs:subClassOf  [ a owl:Restriction ;
```

```
    owl:minQualifiedCardinality    "0"^^xsd:nonNegativeInteger ;
    owl:onClass :Deck ;
    owl:onProperty cmo:hasPart ] .
```

Typical properties

In OWL ontologies Classes and Properties are fully independent. In other modelling language one typically defines properties in the context of a class (like in EXPRESS: 'Explicit Attributes' in the context of an 'Entity'). Not so in OWL: any property can be a property of any class, unless restricted explicitly (i.e. via a domain restriction for a property). This holds for both datatype properties and object properties. The same approach we used for typical parts we apply to typical properties (now non-qualified, i.e. no use of "owl:onClass"):

EXAMPLE

```
:Bridge
  rdf:type owl:Class ;
  rdfs:subClassOf [ a owl:Restriction ;
    owl:minCardinality
      "0"^^xsd:nonNegativeInteger ;
    owl:onProperty :height ] .
```

This approach can be used for both datatype properties and object properties (standing for typical relationships in that case).

3_Energy Ontology

3.1_Introduction

The Odysseus dynamic Energy Profile Card (dEPC) ontology or simply the "Odysseus Energy Ontology", is an advanced information structure covering a variety of information types relevant for improved energy-efficiency in a city's neighbourhoods covering entities like buildings where people perform functions (executing processes, activities, actions, ...) enabled/supported by functionalities provided by appliances under the right indoor climate conditions:

- Energy: roles like producing, consuming, storing energy, played by: …
- Matter: physical things on two aggregation levels like:
  - Entities like buildings or windmills but also
  - Devices like sensors, measuring space conditions; energy meters, measuring energy flows, and actuators like a radiator that condition: …
- Space: conditional areas like building spaces (optionally grouped into zones, externally influenced by outdoor climate/weather).

These three aspects (energy, matter, space) are detailed in the next sections.

3.2_Energy

An energy network is a set of energy nodes and energy connections, where each energy connection connects two energy nodes with a direction. Energy nodes comes in five flavours:

- Energy production nodes,

- Energy consumption nodes
- Energy logistic nodes like switch nodes, controlling the flows between energy nodes (blocking certain connections and hereby stopping an energy flow or making the energy flow take a specific path in case of multiple choices)
  - Energy storer nodes where energy can stay over time, and
  - Energy transformer nodes, which do not consume or produce energy but just transform the energy for the same energy form: i.e. high voltage to low voltage.

The energy connections indicate how energy nodes are topologically connected and determine how energy can flow from one node to another.
Energy Networks (including their energy nodes and energy connections) have a specific energy form. We distinguish:

- Electricity
- Gas ("chemical")
- Heat ("thermal")
- Wind ("kinetic")
- Solar ("radiance")

3.3_Matter

Like energy nodes we have "material nodes" that have a relevance in energy management. Sometimes they fulfil one or more energy roles, sometimes they measure conditions (sensors) or energy flows (meters).
Material nodes can be seen on multiple levels of aggregation of which we select two:

- Neighbourhood Level, where the energy node roles are played by the (energy) installations of Entities like buildings, windmills, systems etc., and
- Entity Level, like the Building Level, where the energy nodes roles are on a lower detail level and played by Devices like appliances or installation parts like energy infusors (like radiators) or energy extractors (like generators)

The cities and neighbourhoods can also have energy consumption and production etc. as a whole but are not modelled explicitly (they are not considered playing an energy node role in some higher aggregation level). Energy properties for these levels can be obtained by querying the existing levels on-the-fly.
A building as special kind of entity has typically various installations covering various energy forms including electricity, gas and heat, that all consists of zero or more devices. The hierarchy of the decompositions of the energy networks having different energy forms is at building level strongly correlated with the energy node interaction of the energy flows in the energy connections. This makes it possible to state that the 'energy consumption-production' of a certain form by a system is always the summation of the 'energy consumption-production' of its direct parts. Examples of special kinds of infusor devices are:

- Radiators, increasing the temperature of a building space,
- Cooling Systems, decreasing the temperature of a building space,
- Lightings, increasing the illuminance of a building space,

- Blinds, decreasing the illuminance of a building space,
- Humidifiers increasing the relative humidity of a building space.

Sensors and Meters

Outdoor climate/weather conditions of the neighbourhood where the entity (like a building) is located, or indoor climate conditions of building spaces can be measured by sensors. The mentioned infusors/extractors effecting the indoor climate conditions of associated building spaces but also other devices like appliances and meters/sensors themselves consume and/or produce energy. This energy consumption/production can be measured indirectly by energy meters that are associated to energy flows as signals for energy connections between energy nodes.

A special case of Signal is a ProfileSignal being a discrete time series of TimePointSignals (being themselves Signals and related to simple 'base' or more complex 'derived' quantities (having units) with a time stamp) where quantities refer to the above mentioned space conditions and energy node/energy connection energy properties (energy consumption, production, flow etc.). For each signal we can optionally indicate:

- valueType: Required, Expected or Measured (default: Measured),
- valueKind: Instant, Incremental, Accumulative, Average , Minimal" or Maximal,
- valueOrigin: Asserted or Inferred (default: Asserted).

3.4_Space

Spaces are outdoor or indoor areas (referred to as building spaces) which typically need certain conditions for activities that have to be performed in them. This is why we refer to them in this context collectively as "conditional areas". Buildings consist of one or more building spaces as conditional area. Furthermore, buildings can have zero or more (horizontal, vertical or mixed) zones that group a minimum of two building spaces into zones. Note that grouping is not the same as (strong) decomposition: when a zone is deleted, the rooms are still there; also the building spaces can be "part of" multiple zones.

A building space or outdoor area has a set of optional conditions that together form its indoor/outdoor climate like temperature, relative humidity, CO_2 level and illuminance. These conditions are (given structural factors like wall types, roof isolation, room/zone topology, glazing types) determined by, external dynamic factors like the outdoor climate/weather conditions for the relevant neighbourhood, internal dynamic factors (occupation, appliances used) and finally the actuators/extractors. Next to the 'entity-level' conditional areas, we also distinguish 'device-level' conditional areas.

Energy Converters are special cases that transform one form of energy into another form of energy involving infusors, extractors and an actual carrier. Examples of convertors are:

- GasBoilers (gas > heat)
- Combined Heat Power (CHP) systems (gas > heat + electricity)
- SolarBoilers (solar > electricity)
- WindMill (kinetic > electricity)

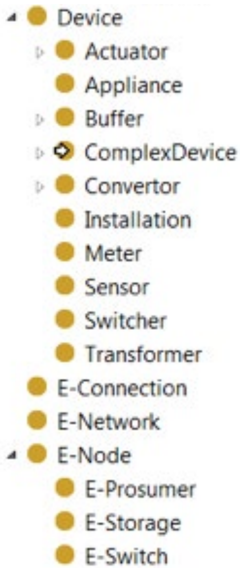

Figure 4. Taxonomy fragment of the dEPC ontology.

All this knowledge is encode in a dEPC Ontology (or "Energy Ontology") according to the modelling guidelines of section III using the TopBraid Composer ontology editor (Figure 4).

4_Semantic Server (OSS APACHE MARMOTTA)

The dEPC ontology is uploaded to a Semantic Server. This server acts as a SPARQL-endpoint which can answer queries over the web. The chosen open source server is Apache Marmotta although alternative experiments are performed using Stardog and Joseki/Fuseki. Beside the ontology we filled the triple store with example data for both a neighbourhood-level and a building-level situation.

Figure 5. Marmotta data overview.

Hereby a small fragment of the Turtle file for the neighbourhood:

```
:Neighbourhood_1
  rdf:type depc:Neighbourhood ;
  cmo:hasPart :Battery_1 ;
  cmo:hasPart :Building_1 ;
  cmo:hasPart :Building_2 ;
  cmo:hasPart :Building_3 ;
  cmo:hasPart :Building_4 ;
  cmo:hasPart :Building_5 ;
  depc:playsRoleOf :Prosumer_1PE ;
  depc:playsRoleOf :Prosumer_1S ;
```

In the details we find the actual energy consumption data encoded as ProfileSignalss containing data for time points according to the specified interval:

```
:TimePointSignal_B1-P22
  rdf:type depc:TimePointSignal ;
  depc:eProduction "0.00"^^xsd:float ;
  depc:timeStamp "2014-05-18T22:00:00Z"^^xsd:dateTime .
:TimePointSignal_B1-P23
  rdf:type depc:TimePointSignal ;
  depc:eProduction "0.00"^^xsd:float ;
  depc:timeStamp "2014-05-18T23:00:00Z"^^xsd:dateTime .
```

We can query all this data via the web-interface of Marmotta where all data can be visualized (figure 6) and queried (figure 7) at (3).

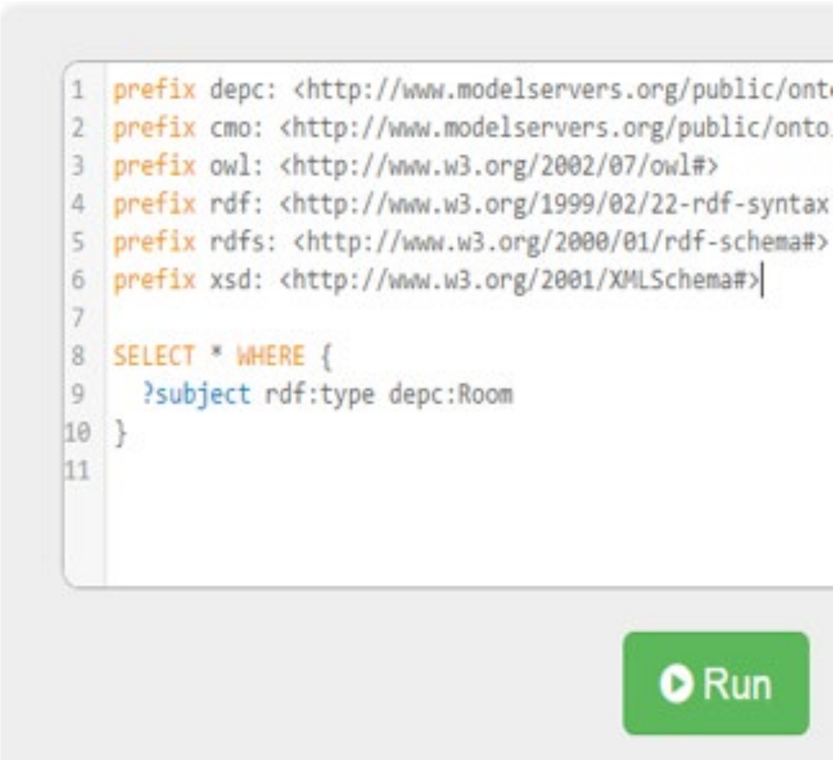

Figure 6. A simple SPARQL query.

Figure 7. SPARQL results (here in JSON-LD-format).


```
{
   "head": {
      "vars": [
        "subject"
     ]
  },
  "results": {
     "bindings": [
       {
         "subject": {
           "type": "uri",
             "value": "http://www.modelservers.org/public/ontologies/odysseus/
building-example.ttl#Room_1"
         }
       },
       {
         "subject": {
           "type": "uri",
             "value": "http://www.modelservers.org/public/ontologies/odysseus/
building-example.ttl#Room_2"
         }
       },
       {
         "subject": {
           "type": "uri",
             "value": "http://www.modelservers.org/public/ontologies/odysseus/
building-example.ttl#Room_3"
         }}]}}
```

In figure 7 the results from the SPARQL query are depicted in JSON-LD format showing the three rooms available in the data. These room can be used as context for further energy-related questions slicing and/or aggregating the energy consumption/production time series available.

5_Conclusions

The Linked Data approach involving Semantic Web technologies seems to be the ideal (open, flexible, well-defined, powerful) approach for modelling energy-related aspects of neighbourhoods and its relevant entities like buildings. The resulting ontologies and data are fully independent of any software application or platform and can be utilized in many ways including monitoring and decision support for energy management resulting in reduction of energy consumption and CO_2 emissions on multiple scale levels.
The actual application scenarios involving Key Performance Indicators (KPIs) and Energy Conservation Measures (ECMs) are described in a separate Odysseus paper.

6_Abbreviations Used

BAS	Building Automation Systems
BIM	Building Information Modelling
CMO	Concept Modelling Ontology
dEPC	dynamic Energy Profile Card
ECM	Energy Conservation Measure
GIS	Geo-spatial Information Systems
JSON-LD	JavaScript Object Notation for Linked Data
KPI	Key Performance Indicator
LD	Linked Data [W3C]
MG	Modelling Guide
OSS	Open Source Software
OWL	Web Ontology Language [W3C]
RDF	Resource Description Framework [W3C]
SPARQL	SPARQL Protocol and RDF Query Language
Turtle	Terse RDF Triple Language [W3C]
W3C	World Wide Web Consortium

7_References

(1) http://www.odysseus-project.eu/
(2) http://www.w3.org/standards/semanticweb/data
(3) http://marmotta.tno.nl:8080/marmotta/
(4) http://odysseus.tno.nl:8080/webprotege/

Abstract

The Odysseus Project is developing a decision support system (Open Dynamic System) for the management of energy supply, demand and storage in urban areas using an open integration platform.
The overall project objective is to increase neighbourhood energy efficiency, reduce the CO_2 emissions and address issues of an "energy positive neighbourhood" (defined as an area that produces more energy than it consumes yearly average). For this purpose Odysseus has developed an ICT tool to deliver modelling, analysis and monitoring of energy performance and emissions of buildings and neighbourhoods.
The solution was experimented in two pilots cities: Manchester and Rome. The Manchester pilot is a mature energy environment, while Rome is in the early stages of dealing with energy efficiency in public buildings. Objectives of the experimentation is also to find a way (methodology for validation) to certificate the energy efficiency achievements made in these scenarios and then identify the step necessary to reproduce the energy saving goals in other districts or cities.
This is done with a specific approach based on the developed methodology representing the findings for future scale up of implementation of Odysseus system.

ENERGY CONSUMPTION REDUCTION IN URBAN AREAS

The Rome and Manchester Odysseus cases and ways forward for a replication in other cities

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Rome
energy saving methodology
neighbourhood energy efficiency

1_Odysseus objective and experimentations

Odysseus is developing a decision support system (Open Dynamic System or ODYS) to support the management of energy supply, demand and storage in urban areas using an open integration platform.
The goal is to provide a service for decision-making by aggregating data from a range of sources in a cloud platform providing a holistic overview of a neighbourhoods energy system. The decision support system (ODYS) addresses the dynamics of energy supply and demand in neighbourhoods and optimises the use of energy beyond individual elements (for example, urban heat production and electrical vehicles) by enabling the integration of renewable energy sources and the connection to the electricity distribution grid.
This solution has already been experimented in two cities: Manchester and Rome. In both cases a scenario was defined and specific use cases were developed with a common path: the definition of a baseline for the experimentation, the set-up of goals and KPIs to identify energy efficiency goals and the simulation (with Odysseus platform services) to derive best measures to reduce energy consumption or CO_2 emissions.

1.1_Manchester city Pilot case

The experimented case in the city of Manchester was divided in two cases:

1. The Town Hall Extension (THX) Use case
2. The Civic Quarter Heat Network Use case

The first case is based on "soft measures" focused on the change of user behavior and management practices by the Manchester City Council occupants (MCC employees). These measures (energy conservation measures - EMCs)

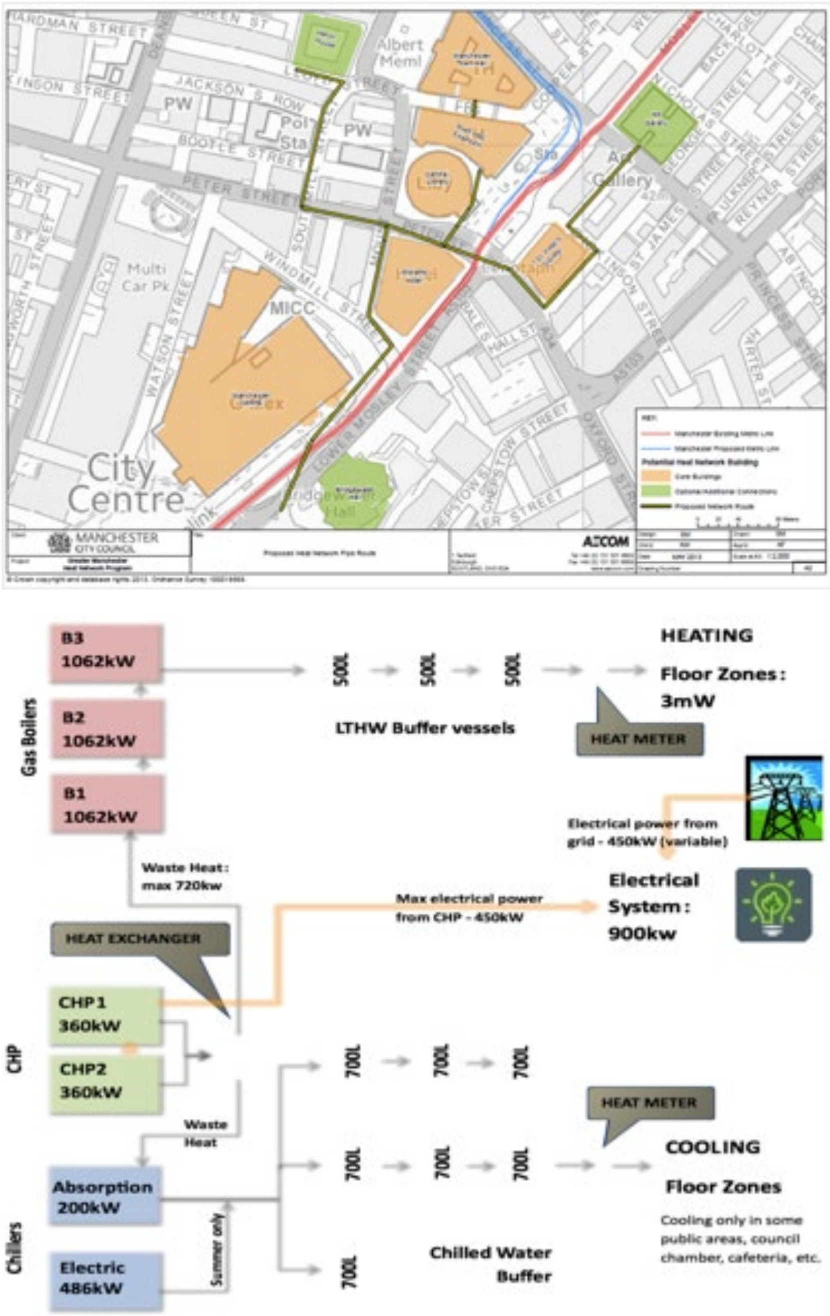

Figure 1. Manchester case buildings and energy flow.

are elaborated over a comparative study for the implementation of more efficient operations in the building energy related procedures. Sensors were placed in the zone involved by energy reduction measures and after a baseline period of experimentation and a technical ECM solution resulted (namely the installation of a master control in the BEMs to switch lights off out of office hours, i.e., overnight and at weekends).

The second case concerned the Manchester Town Hall Extension Complex (THXC) consisting on the Town Hall Extension and the Central Library. The buildings share a common plant room where the main power source is provided by two gas fired CHP[1] engines.

In the winter heating season both engines can be operated to supply 50% of both building's electrical requirement, about 24% of the space heating requirement and via an absorption cycle chiller operating overnight, (when

[1] Cogeneration or combined heat and power.

space heating of the office floors is not required) providing cooling to some of the public areas.

In the rest of the year one of the engines is shut down because there is more ("waste") heat when both engines are operating than there is space heating and cooling requirement. When one engine is down it means additional electricity has to be purchased from the grid. In the summer at current gas prices (i.e. summer 2015) it would be cheaper to run both the CHP engines to generate electricity and vent off the heat.

The energy managers wish to address the issue of more effective use of the CHP and waste heat in spring, summer and autumn and investigate the feasibility, cost and energy benefits of exporting heat during these periods to the adjacent MAG[2] and/or to the additional energy storage in the proposed new energy centre to be created in the basement of Manchester Central.

The main energy conservative measure (ECM) to be applied and evaluated is a simulation of an extension of the heat network from within the THXC to MAG and Manchester Central.

The case was useful to explore the following additional measures:

1. Relative contribution of heat and electrical energy from the THX to the gallery and how much of the gallery's space heating, domestic hot water and electrical load could be met;
2. Optimisation of the hot water systems in the THX and buildings to minimise energy use to relate to various climate conditions in the non-heating seasons (spring through summer to the autumn), including the use of increased energy storage in the new energy centre;
3. Return on investment in the construction of the network, additional plant and equipment including increase energy storage capacity in relation to a reduction in electricity drawn from the grid for the THX, and reduction in gas for space heating and domestic hot water heating in the gallery;
4. Overall increase in energy efficiency and decrease in CO_2 and the potential contribution to meeting MCC's CO_2 reduction target;
5. Effects of fluctuations in energy prices (gas and electricity tariffs) as well as anticipated future changes in the energy market in the UK and the potential effect this will have on return on investment.

1.2_Municipality of Rome pilot case

Municipality of Rome case was based on the following involved districts and buildings:

- Garbatella neighbourhood:
  - Cesare Battisti School (Building A) - Damiano Sauli Square, n. 1, 00154
  - Cesare Battisti Offices (Building B) - Damiano Sauli Square, n. 1, 00154
  - The Technical and Operating Unit (U.O.T.) - Sette Chiese Street, n. 23, 00145
- Montagnola neighbourhood:
  - Institutional Seat of the town hall Rome XI (Building A) - Benedetto Croce Street, n. 50, 00142
  - Institutional Seat of the town hall Rome XI (Building B) - Benedetto Croce Street, n. 50, 00142
  - Nursery school I Monelli - Casalinuovo Street, n. 32, 00142

[2] MAG consists of three interconnected mainly three storey buildings; a neoclassical building completed by Sir Charles Barry in the Greek Ionic style in 1835 and originally the Royal Manchester Institution, the adjacent Athenaeum Building completed in 1837 and a new extension and refurbishment of both older Victorian buildings by Hopkins and Partners completed in 2002. The complex's HVAC system was installed in 2002. All galleries are fully air-conditioned and some storage and office areas also have temperature and humidity control.

Figure 2. Rome case buildings and districts.

    - Kindergarten Ciliegio Rosa - Accademia Aldina Street, n.30, 00147
- S. Paolo neighbourhood:
    - School Livio Tempesta - Salvatore Pincherle Street, n. 140, 00146
    - Kindergarten Aquilone Colorato - Giustiniano Imperatore Street, 00145

Base on these premises, 8 cases were developed:

1. Cesare Battisti school
2. UOT Sette Chiese
3. Livio Tempesta school
4. Institutional Seat Building A
5. Institutional Seat Building B
6. I Monelli Building
7. Ciliegio Rosa
8. Aquilone Colorato

The cases involve each one a sub-set of the listed buildings but they share the common objective. This is to assess, through monitoring of electricity consumption and the electric energy produced by the Photovoltaic panels, the reasonable and simulated actions (technically and economically feasible), to be achieved for a reduction of electricity consumption and an increase of the electric energy generation, in order to have a sufficient surplus of electric energy. This surplus can be transferred to other buildings or, in some case, recharge the batteries of electric bicycles available in the Municipality main building.

After the evaluation of energy consumption by the Odysseus system the following actions resulted:

- Replacement of fluorescent lamps with LED lamps in some areas of the building;
- Installation of forecasting automatic light-off devices for the reduction of the illumination depending on the light.

2_Energy Saving Measurement assessment

Before introducing the concept of replication and scale up of the proposed pilots an overview on what are energy saving measurement has to be presented.

Energy savings cannot be measured directly because the targeted scenarios might be different over time, so in this circumstance, it is always necessary to compare between different situations. A more practical approach is to setup the calculation of the energy savings using a standardized calculation methodology that supports comparisons of energy savings in a homogeneous way[3]. Based on the experimentation conducted a methodology was developed basically addressing how to go "from facilities level towards an upper level scale like the neighbourhood of a city".

Is it based on the following assumptions:

- The scenarios evaluated with the project pilots (i.e. Manchester and Rome pilots) have the same characteristics (variation of Energy Consumption during the Baseline Period is closely replicated by the variation of Energy Consumption during the Test Period and each period includes a representative range of conditions that significantly impact Energy Consumption);
- The experimentation is based on facility level;
- The experimentation is conducted over a period of one year.

The following 12 steps summarizes the methodology:

Steps	Description	Phase
1	Define the set of project boundaries for the pilot site: energy- system(s)/e-Node(s) definition.	Monitoring
2	Select the predictor variables to be applied on the pilot site	Monitoring
3	Set the baseline period for the pilot site without improvements and optimizations at neighbourhood level	Monitoring
4	Deploy monitoring hardware (e.g. gateways, sensors and actuators) for energy-systems /energy nodes (e-Nodes) at facilities level in the pilot site (e.g. floors, buildings) in order to monitor predictor variables (e.g. energy data).	Monitoring
5	Collect and store raw data of predictor variables an energy-systems / eNode (facilities level scale)	Monitoring
6	Transform raw data into dEPC information structure	Monitoring / Baseline analysis
7	Perform initial baseline analysis at energy-system / eNode level (facility level)	Baseline analysis
8	Connect e-Nodes to the aggregation layer of the Odysseus Cloud Platform. From e-Node to e-Network	Extended boundaries to e-Network
9	Send e-Node dEPC information (real information) to the Odysseus Cloud Platform to compose the e-Network level (simulated). Analyse and conclude the neighbourhood baseline period for the pilot site with this information). Note: At this step we will have a neighbourhood level scale vision.	Extended boundaries to e-Network / Baseline analysis
10	Apply the identified ECMs at e-Node level (facility level scale) (e.g. building)	ECMs / Reporting
11	Apply the identified ECMs at e-Network level (Odysseus Cloud Platform simulation) Note: At this step we expect to have the Odysseus Cloud Platform and the integrated versions of energy efficiency tools. We will provide a holistic energy management vision of the neighbourhood.	Extended boundaries to e-Network / ECMs / Reporting period
12	Evaluate the obtained results at e-Node level (facilities level) and e-Network level (neighbourhood level) by comparing baseline and reporting periods.	Evaluation period

[3] The ODYSSEUS Open Cloud Platform (OCP) supports both 'tactical' and 'operational' energy-related decisions. This definition is related to the Odysseus System (monitoring, simulation, ontology) and the identification of a scenario. An Odysseus scenario is defined by:
1. A context, the set of all relevant external/given factors;
2. A spatial Scope;
3. A temporal Scope ("Time Span" where special conditions can be added)

Manchester and Rome pilot experimentations were conducted having such methodology as main track. The 3 main points below exemplify the activity performed based on what the methodology suggest as way of proceeding:

1. Reference the general methodology (intended in a simple way the set of concrete activities to be performed for energy reduction demonstrators)
2. For each methodology phase identify what was done and:
   a. Evaluate the activities and if they were appropriate for the overall objective
   b. Identify with that instruments / tool the activities was performed or could have been performed
3. Analysis of the tools developed in Odysseus and adopted for energy saving targets.

Each phase of the methodology applied in the pilots is related to one or more specific Odysseus services. This is important also for the pilot scale-up as explained in the following document sections. The pilot validation is also aimed at identifying the benefits in energy saving obtained with the adoption these services.

Thus base for the energy efficiency pilot replication (on the basis of what done within the Odysseus project) crosses the following points:

- What tools / services have been adopted for the described methodology phase (and the relation with the overall Odysseus architecture);
- How the services were utilized in the specific phase;
- What are the advantages the adoption of the services has brought in the pilot overall results and more in general in the energy saving or CO_2 emission reduction.

3_Energy efficiency pilot replication

The experimentation replication can be developed in two ways:

- Vertical: extending the pilot results in other cities, with more instruments, different energy saving experimentations;
- Horizontal: extending the same pilot experimentation to other organizations, other buildings in the same district etc.

The first element to address to replicate a pilot "is how Odysseus can help the objective of Energy consumption or CO_2 emission reduction". As said the first answer to this is to reference to dedicated developed:

- Guidelines
- Methodology
- Odysseus tools / services

Based on that the replication can proceed through the following three successive steps:

1. Guidelines for the establishment of a scenario considering the element involved in the pilot (network, buildings, energy nodes etc.);
2. Definition of goals and KPIs to assess Energy Reduction achieved with the Odysseus tools / services adoption;
3. How and what simulation is available for the assessment (and in case the adoption) of the proposed Energy Conservative Measures (EMCs)

3.1_Phase 1 - Guidelines for the scenario establishment

For the scenario establishment, the activity performed during the Odysseus pilot, can be considered as master track especially for the experience achieved for:

- The sensors installation (what buildings are involved and/or what part of the building(s));
- The information collected and exchanged by the sensors;
- The data collection frequency;
- The baseline period for the experimentation;
- How data are aggregated and interpreted;

3.2_Phase 2 - Definition of goal and KPIs

The second phase for the experimentation is related to the goal of energy reduction to achieve with the experimentation. This phase has to respond to the following questions:

- How are the goals (energy, costs or CO_2 reduction);
- How to define KPIs to assess such goals (and how these parameters are correlated to the energy nodes involved)
- How can I assess the final measures to calculate the effect of ECMs implemented

3.3_Phase 3 - Simulation and Energy Conservative Measures assessment

Last phase involves the Odysseus tools or services developed to execute the simulation and derive information from what Energy Conservative Measures adopt and what is the advantage of them.

Odysseus solution is helping then in identifying the potential activities to be performed in the pilot for energy saving goals defined in the previous phases. The Odysseus simulation service is finally able to determine what of the different solutions proposed is the best to apply (proposed to the facility manager) and to put in place.

4_A replication example

The activity performed in the Odysseus experimentation and the results achieved in Energy Conservative Measures adoption at neighbourhood level are already interested by concrete initiative such as the **"People Olympics neighborhoods competing for their city energy smart living, fun and social transformation"** proposal (to be launched in Q4 2016 / Q1 2017).

The initiative, leveraging EU H2020 Programme ('Secure, Clean and Efficient Energy'), is based o a game where competing cities tracks their energy smart living activity in terms of reduction of energy consumption and increase and sharing of local energy production. A system collects all data and updates the real time cumulative energy smart living activities at city level, and compares it with the value of the other competing cities.

People and the city ecosystem will engage in producing renewable energy and in co-creating services to use the energy in efficient and innovative ways

(for example energy produced by photovoltaic private and public installations can be used for charging fleets of electric bikes in a collective mode).
The active involvement of citizens is supported by an educational and fun game based on 7 levels:

1. Accept challenge (registered to the game);
2. Describe your house energy profile card (energy card completed);
3. Monitor (monitoring equipment installed);
4. Become aware (baseline completed);
5. Become conscious of your potential (opportunities identified);
6. Decide (what and how);
7. Action (deploy decided ECM);
8. Enlightment (realize benefits).

The idea is to have a group of residents in a neighbourhood to play against other city groups to share and spread Energy Conservative behaviour and best practices and measure and assess the benefits (achieved at city level) with the Odysseus holistic energy management system.

5_Conclusions

Thanks to the Odysseus pilots and experience achieved with the experimentations in Rome and Manchester, the replication is possible with the exercise of deriving all the necessary elements that made these cases compliant with the 12 steps Methodology. In the specific (as seen in the 3 phases):

- How to identify case system (and energy nodes);
- How to build baseline(s);
- How to define realistic energy saving objectives;
- How can defined objectives can be related to energy parameters and building constraints;
- How to derive a list of actions (ECMs);
- How to chose between the different actions for the most effective ones (with all the experimentation variable set)
- Execute simulation for the pilot replication

The simulation service(s) can finally analyze all the Energy Conservative Measures experimented to allow the definition of the best solution to put in place for realistic changes in CO_2 emissions reduction or more efficient use of energy network, energy surplus and distribution.
Odysseus challenge has just started; more and more cases for sustainable energy efficient districts are just around the corner.

6_References

Odysseus Project – Description of Work (600059) 2012-09-26
Odysseus Integration scenario & dEPC Requirements
Rome and Manchester pilot demonstration Plans in the Odysseus Project
Odysseus Pilot Business Cases
Odysseus Evaluation of Demonstrators
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Abstract

The paper presents the Odysseus Pilot executed in Rome. Odysseus is an EU project that seeks to develop an energy support system tool for urban districts: www.odysseus-project.eu.
Odysseus has two pilot sites, Manchester and Rome, where energy data has been collected by a monitoring system in order to feed the software tool that has been developed: this paper reports on the Rome pilot-The eight Municipality of Rome.
The Pilot objectives are: obtaining energy savings, reducing of energy wasting and CO_2 emissions, obtaining the energy surplus and the most efficient use of the energy excess. Results are discussed highlighting the energy savings achievement using Odysseus solutions.
The Rome demonstration, similar to that of Manchester, consists of two main parts. The first explores the energy efficiency improvements to a single building, the Cesare Battisti School. The second part explores the wider neighbourhood of public sector educational buildings in the district of Rome involving a total of eight buildings in addition to the Cesare Battisti School (BU1).
This includes a number of buildings used for teaching and educational purposes. Some of these buildings have been equipped with photovoltaic arrays (BU's 1,3,5,6) and two of them BU2 and BU5, with electric cycle facilities (i.e. bikes and charging points). The objective of this second part of the Rome demonstration is to simulate more efficient use of the electrical energy produced by the photovoltaic arrays by transfer of the surplus to the e bikes and/or other buildings, through a simulated independent sub-grid which could make the buildings, for some periods of the year, independent of the main power grid.

ODYSSEUS OPEN DYNAMIC SYSTEM FOR HOLYSTIC ENERGY MANAGEMENT

A case pilot from the VIII Municipality of Rome

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1_Introduction

The paper contents are:

- A description of the referring buildings within the boundary object of the analysis;
- The Energy system of the referring buildings;
- Description of the monitoring infrastructure. E-consumption meters and P.V. meters;
- The independent e-Grid;
- The decision support system and Energy savings opportunities;
- Conclusions.

The 7 referring public buildings are located in The VIII Municipality of Roma Capitale. The buidings involved are:

- UOT Sette Chiese - BU2
- Livio Tempesta School - BU3
- Institutional seat of the eight Municipality of Rome - building A - BU4
- Institutional seat of the eight Municipality of Roma - building B - BU5
- I Monelli school - BU6
- Ciliegio Rosa school - BU7
- Aquilone Colorato school - BU8
- Cesare Battisti School - BU1

Building	Code	Photovoltaics	e-Bikes/Charging
Battisti School	BU1	Yes	
Uot Sette Chiese	BU2		yes
Livio Tempesta School	BU3	Yes	
Institutional Seat building A	BU4		
Institutional Seat building B	BU5	Yes	yes
I Monelli	BU6	yes	
Ciliegio Rosa	BU7		
Aquilone Colorato	BU8		

We have different levels of energy nodes: 4 buildings are both energy generation and energy consumption nodes and 3 of them are energy consumption nodes; in fact, the energy is provided by the supply provider Acea Distribution and for 4 of them energy is also provided by their own PV Plant: Cesare Battisti School, the Institutional seat of the eight Municipality of Rome, I Monelli school, Livio Tempesta school.

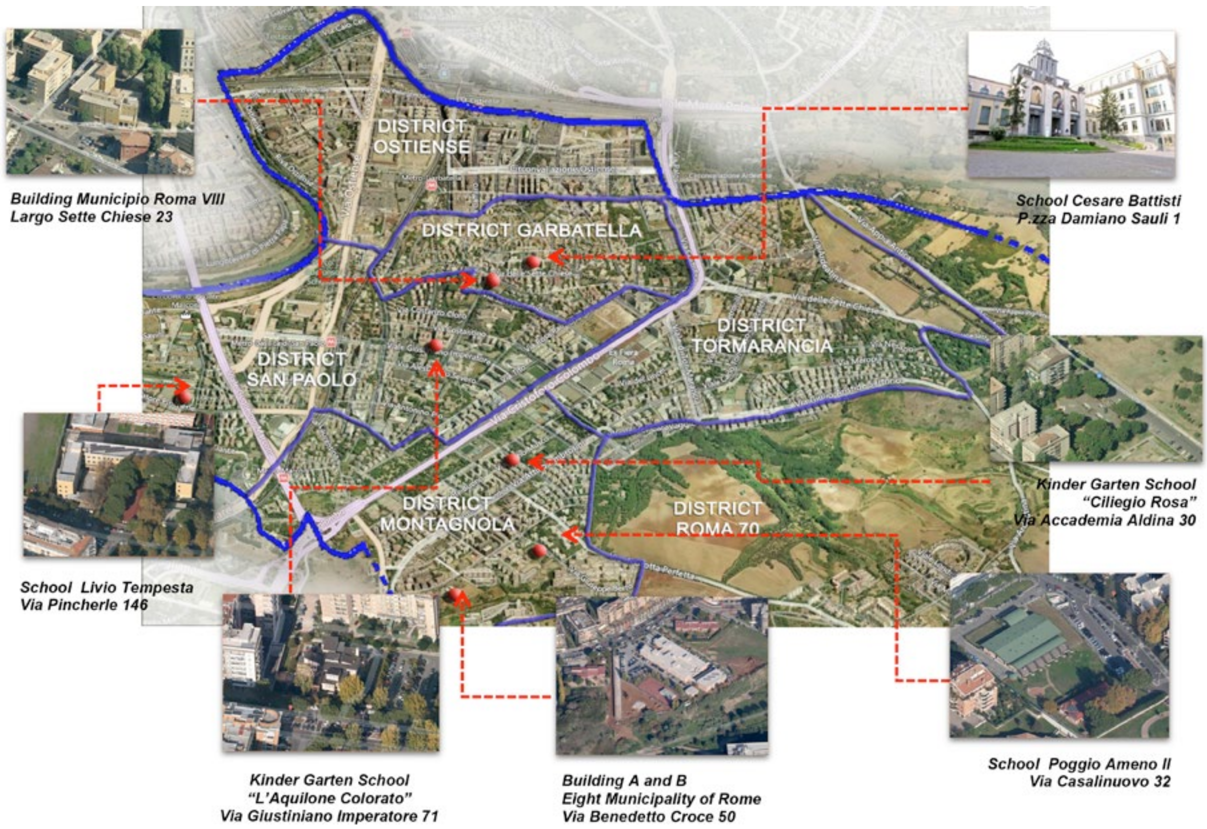
The energy consumption and generation of the 7 buildings is continuously monitored and measured by the meters installed in place that provide a detailed analysis of energy consumption, energy generation and energy wasting, gathering data on field.

The location of the monitoring System is shown in figure 1.

Some of these buildings are equipped with Photovoltaic arrays BU1 Cesare Battisti school, BU3 Livio Tempesta School, BU5 Institutional Seat of the eight Municipality of Rome, BU6 I Monelli school and two of them with electric bikes and charging points.

From an electrical point of view the current situation is that the energy is provided by the Utility distribution (the supply provider) and by the P.V. panels.

Figure 1. Location of the monitoring System



The energy produced in excess is given back to the Utility grid.
Data are sent to the platform and processed and analyzed by Odysseus tool. Odysseus recommends the most efficient solution to obtain the desired results suggesting the solution to archive energy savings and the most efficient use of the energy in excess – replacement of fluorescent bulbs with led (identifying the number-zones-building)/ transferring energy surplus from one building to another identifying the energy demand/profile of the building to supply energy required, without giving back to the Acea grid or recharging the batteries of the electrical bicycles-simulating bidirectional energy flows through an independent grid of energy exchange – an integrated energy management system.

2_Summary description of the use case, aims and objectives

Odysseus project holistic Energy management system.
It is the decision support tool for urban districts that supports the management of the dynamics of energy demand and supply. It is an integrated open dynamic system based on scenarios for designed urban areas and it is exemplified in the cities of Roma and Manchester.
In Rome Odysseus covers the monitoring of dEPC – dynamic energy profile card – that, as an energy identity card, feeds the info of the dynamic energy behavior of the referring buildings.
The energy info gathered on field through the energy consumption and generation according to the monitoring infrastructure, are stored in an open standard, processed and analyzed by Odysseus, and then through a user interface, recommendations are made as to how to use the energy efficiently.
The goal is to assess through detailed monitoring of the electricity consumption in the building how a number of technical changes (ECMs) focused on improvements to the lighting, can reduce electrical demand and on producing energy in excess.
It also includes how to use the energy produced by the roof photovoltaic array more effectively and hence dependence on energy from the grid. The use case aims to demonstrate the result of obtaining a reduction of electricity consumption and an increase in utilisation of the energy generated by the photovoltaic system. The intention is to use any surplus of energy available to transfer between buildings and to recharge the e-bike batteries. The objective is to evaluate electrical consumption in each of the buildings in relation to their individual floor areas and number of occupants, whilst monitoring of consumption and production in real time (every 15 minutes). This enables an evaluation of the amount of electrical energy to transfer from the photovoltaic installed at BU1, BU3, BU5 and BU6 to other buildings, to the e-bikes, as well as to understand the potential for more energy storage.

3_Monitoring equipment, technology, functionalities

The meters were installed in BU1 and a continuous monitoring phase commenced In December 2013.
Each meter is equipped with an integrated Ethernet card for data connection via LAN and Rogowsky amperometric probes or open amperometric

transformers (TA) installed on the cables. The meters send readings every 15 minutes to a remote portal where the measurement of energy is in kWh.

The monitoring system displays the information retrieved from the monitoring devices. It gathers historic or current measurements in tables and graphical mode, showing trends and displaying data.The energy consumption and generation of the 7 referring public buildings is continuously monitored and measured by the meters installed in the referring buildings. By gathering data on field through a monitoring system, Odysseus processes data and provides a detailed analysis of energy consumption, energy generation and energy wasting. After gathering the data, Odysseus system reports values of the electric energy consumption and production, proposing to the facility manager or decision maker the most efficient actions, even if simulated, that should obtain the desired results, being; the most efficient use of energy saved and/or in excess; recommending the actions to put in place to reduce the energy consumption related to the type of building in relation to the total area and to the number of occupants of the structure such as for instance by replacing bulb lamps with led lamps; identifying the building in order to transfer the energy to in excess satisfying the energy demand; recharging the batteries of electric bicycles.

Through the monitoring system, and static data acquired, Odysseus describes the dynamic energy profile of the buildings (dEpc) a software as an energy identity card listing its needs.
Odysseus tools are:
The monitoring system;
E connect tool that shows AS IS situation – used to compare energy needs of the buildings – describers the energy profile of buildings;
Eve city that provides simulation comparing a current situation to a simulated one after the implementation of ECM's. The eveCity interface offers a list of predefined ECMs from which the user can select to apply to individual buildings. Having made these choices, the simulation can be run as above.
The energy performance behaviour of the district before and after the ECM(s) can be compared using the yearly results and the KPI values of the two scenarios (representing supposedly the "as-is" and "to-be" situations).
The monitoring system and the suggested actions after the analysis of energy data by Odysseus through the tools above described consist in the evaluation of energy savings opportunities measured by common KPIs before (baseline period) and after (reporting period) the implementation of the suggested ECMs measures.
Odysseus is an important tool that supports the decision maker, suggesting through the monitoring system, the description of the energy profile and needs of the referring buildings, the dEPC, and the simulation tool eve dimo sim, the most efficient actions to generate energy saving opportunities. Odysseus recommends solutions giving priority to the reduction of energy consumption such as with the replacement of Bulbs with LEDs. Secondly, it increases the surface of the PV panel in order to obtain the production of energy i.e. energy surplus and suggesting the most efficient use to allocate energy surplus to the other buildings (energy saving opportunities).

Odysseus analyses the reported values (data) of the electricity consumption and the production of the electric energy and studies the value measured by the other meters and sends data in real time to the portal of Odysseus.
The evaluation of energy savings opportunities is measured by the KPIs before (baseline period) and after (reporting period) the implementation of the suggested measures.
Odysseus analyses, proposes actions (decision to support the facility manager or the energy manager), even if simulated (dEPC that describes the energy profile of the building), in order to reduce energy consumption and obtain energy self sufficiency or the electric energy in excess.
These recommended actions consist in:

- in case of the replacement of fluorescent lamps with LED lamps, Odysseus suggests the most efficient actions (ECMs). For instance, replacing bulb lamps with led lamps, the optimal and right number of lamps, their power and the areas/zones of the building where they need to be installed t and alternative results of the actions. The scenario is compared and the relating energy savings, costs and benefits.
- in case of the transferring of excess energy from one building to another (depending on the measurements and the needs) supplying its energy demand, at least during the holidays when schools are closed, without giving back the energy in excess to the Acea grid.
- in case of using the excess energy for recharging the batteries of the electrical bicycles a reduction of CO_2 impact is obtained;
- in case of the simulation of bidirectional energy flows for energy generation and energy consumption through a desired independent grid of energy exchange, an integrated energy management system manages the energy surplus in the most efficient way satisfying the energy demand of the other buildings, smartly integrating the actions of all users that are connected.

Figure 2. Grid Dyagram.

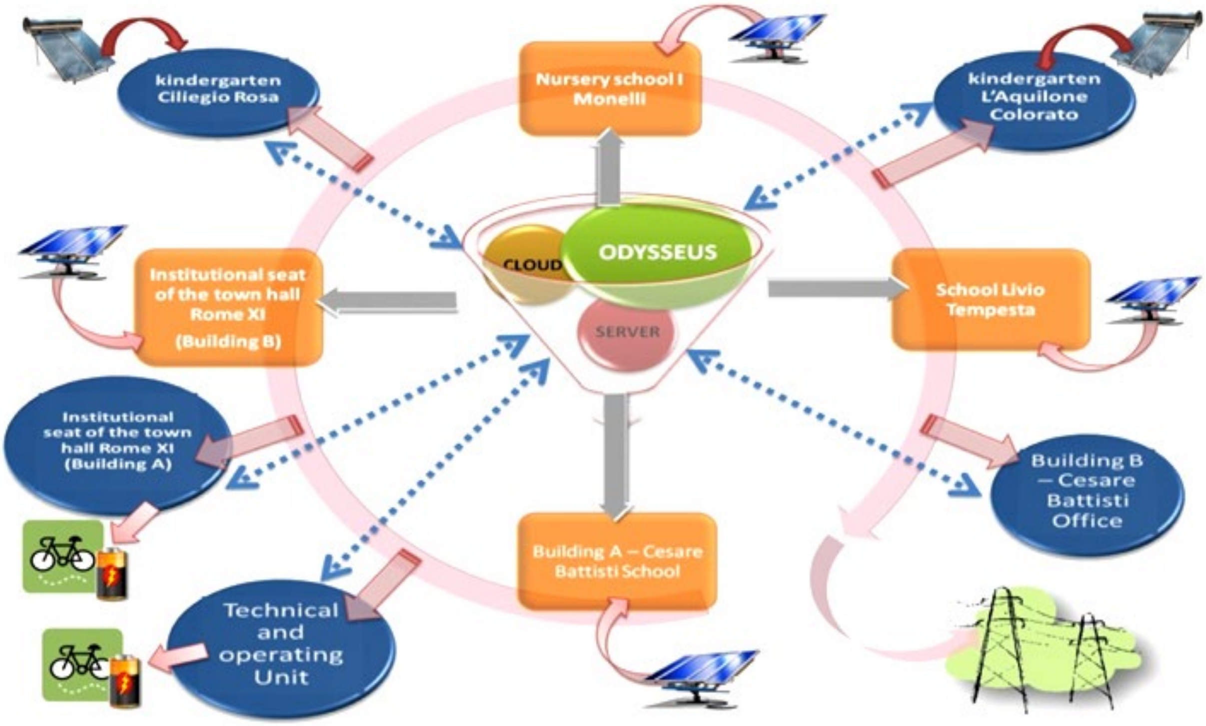


Figure 3. Energy smart grid.

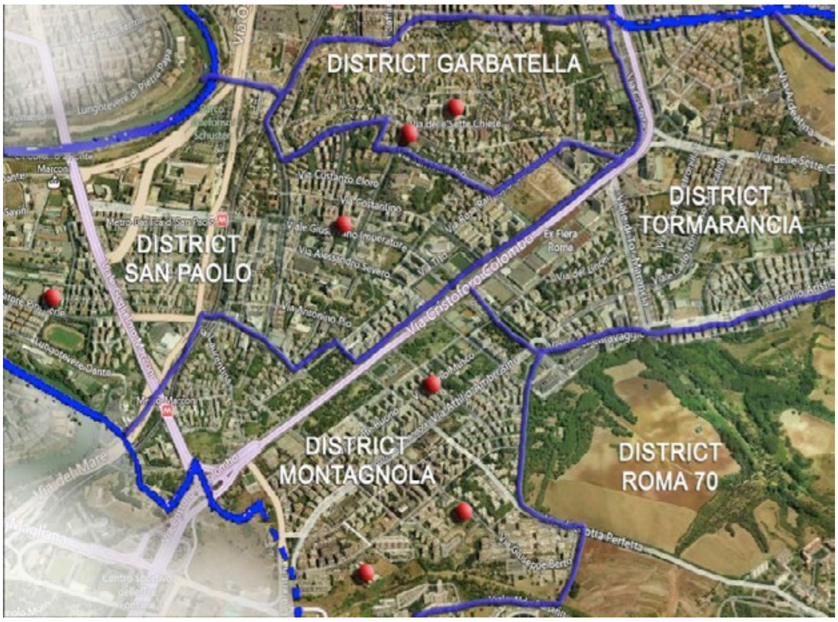


Figure 4. Electric bikes.

4_Conclusions

In conclusion the results of the application of the tools developed in Odysseus which include dynamic energy profiling of buildings and an Urban Energy Management system which are necessary for managing energy flows are provided.

The key tools are:

- The monitoring system
- E connect
- The dEPC
- Eve city simulation tool
- The analysis proposed by Odysseus tools

The comparison of results before and after the implementations of Odysseus recommended actions and the measure of the results by the KPIs:

- Through the monitoring infrastructure and an effective diagnosis of energy waste there is an identification of energy savings in buildings;
- The recommendations of Odysseus as a tool to enable:
- More efficient use of energy surplus;
- Energy self sufficiency of any buildings;
- Identification of energy savings opportunity;
- Reduction of costs (environmental costs and energy costs);
- Efficiency in Strategic decisions (e.g.increasing P.V. power-costs and benefits comparison) – optimal use of public resources – reduction of public expenditure – reduction of CO_2 emissions.

5_References

ODYSSEUS 2016: www.odysseus-project.eu

Abstract

Odysseus is an EU project that seeks to develop an energy management tool for urban districts: www.odysseus-project.eu Odysseus has two pilot sites, Manchester and Rome, where energy data has been collected in order to calibrate the software tool that has/is being developed and where it is to be tested. This paper reports on the Manchester pilot.

In Manchester the project has supported fine grained metering and energy data collection of the recently refurbished Town Hall Extension building (known as the THX) and is using the detailed knowledge of the energy flows to help the development of the proposed Manchester Civic Quarter Heat Network (MCQHN). The nature of the building, its advanced CHP installation, the application of the UK "Soft Landings" in commissioning of the building are explained, particularly the building services aspects. The problems encountered in commissioning and with the Building Energy Management System (BEMS) as well as the security and other barriers to access to data for use in wider Urban Energy Management are also explored.

The conclusion reports the results of the monitoring with regard to Odysseus. These includes dynamic energy profiling of buildings and an Urban Energy Management System as necessary for managing energy flows in the MCQHN and similar urban networks handling the dynamics of weather, energy price fluctuation and occupancy changes. Based on the experience in the THX the potential of simulation in assisting in the design of such urban networks is explored.

ODYSSEUS: MANCHESTER PILOT STUDY

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monitoring

1_Introduction

The aim of the Odysseus project is to develop a 'holistic energy management' tool to support the **management the dynamics of energy supply, demand and storage in urban areas**. An integrated Open Dynamic System (ODS) is planned based on scenarios for designated urban areas and exemplified in the cities of Rome and Manchester. In Manchester project results are being validated in the mature energy efficiency environment of the recently refurbished Town Hall Extension (THX), whilst in Rome it is based on addressing energy efficiency in education buildings.

The concept of holistic energy management covers the monitoring of energy operation in an urban area according to 1) dynamic energy profile information for all relevant 'energy nodes' and 2) the actual conditions and behaviour of all these nodes. Energy nodes can be whole buildings, energy sources such as PV arrays and combined heat and power (CHP) installations or storage such as thermal buffers and electric vehicles including electric bicycles. The application of integrated energy monitoring enables energy efficiency problems to be identified and recommendations for optimisation made. This is also important to the commercial negotiation processes between the stakeholders for long-term decision support to reduce costs, especially for real-time tactical decision making (e.g. to avoid using energy in expensive peak periods) and even for strategic adaptations. This could include adding or changing nodes; e.g. more energy storage; or for optimised usage by changing connections to divert unused power to charge electric vehicles.

The Open Integration Platform will capture all energy node information in a **"dynamic Energy Profile Card"** structured according to a new taxonomy of energy node types and their associated properties and interrelationships. All the data for these information structures and the structures will be stored in an open standards, open source spatial database accessible via standard interfaces so that the system will be flexible, interoperable, adaptable and extensible.
The overall objective of this paper is to review the monitoring and testing that has taken place in the Manchester pilot study and this includes:

1. A description of the building and associated building services that form part of the study in Manchester;
2. An explanation of the problems encountered with the application of fine-grained metering and in the monitoring processes forming part of the Odysseus project linked to the UK "Soft Landings";
3. Description of some of the energy savings made;
4. Suggestions for other researchers working in this area.

2_Manchester Pilot Study

The Manchester Pilot Study is in two parts, firstly, energy monitoring undertaken during the commissioning of the recently refurbished THX and, secondly, simulations undertaken for the proposed Civic Quarter Heat Network. Under the auspices of the Odysseus project the detailed monitoring of some key parts of the THX building has been undertaken from mid-September 2014 to date (December 2015).

2.1_Town Hall Extension Building

The Manchester Town Hall Extension (THX) is an important facility for the city's administration located between the Old Town Hall and the Central library. It is a narrow plan steel and concrete framed building enclosing a courtyard mainly on 8 floors and completed in 1938. It underwent a major refurbishment during the period 2011-13 to bring it up to a modern office standard and has recently been re-occupied. The building is grade II listed, clad in sandstone with steep pitched lead roof. As an important heritage building the options for the improvement to the thermal performance of the fabric were limited. The appearance of the exterior and much of the interior has had to be maintained which, with the narrow bronze frame section of the single glazed windows precluded retrofitting of internal or external insulation. Instead, to address the city's CO_2 abatement target (41% by 2030), the design strategy has been to focus on increasing the efficiency of the new heating and cooling systems and in their control. In addition to a complete internal refit, new metal framed doors were installed together with the refurbishment of the existing metal windows to restore functionality and improve airtightness, but in a manner that maintains the external and internal appearance.

The plant room is located in the basement area and supplies both the THX and the Central Library which were refurbished in parallel. The buildings are connected via an under croft and together are known as the Town Hall Complex

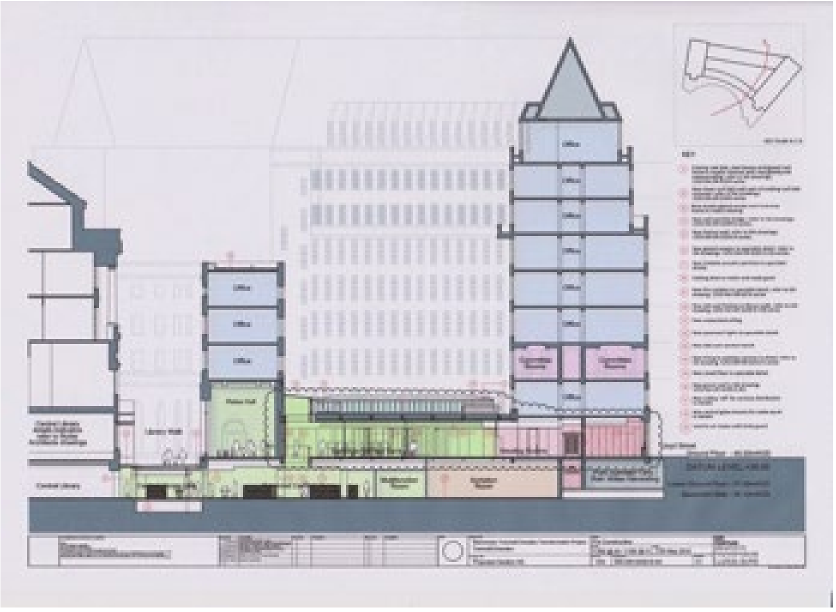


Figure 1. Sectional Elevation of Manchester Town Hall Extension.

(THC). The ground floor and under croft provide a range of public areas including the reception, drop-in centre and cafeteria. As can be seen in Figure 1, the ground floor area of the THX occupies the whole of the footplate of the building and the roof over these public areas has been renewed with well insulated and double glazed construction. However the public areas do not form part of the Odysseus experiment. This has concentrated on the office floors, specifically levels 3, 4 and 5; selected as they would allow direct comparison between floors due to almost identical layout, and similar occupancy and aspect.

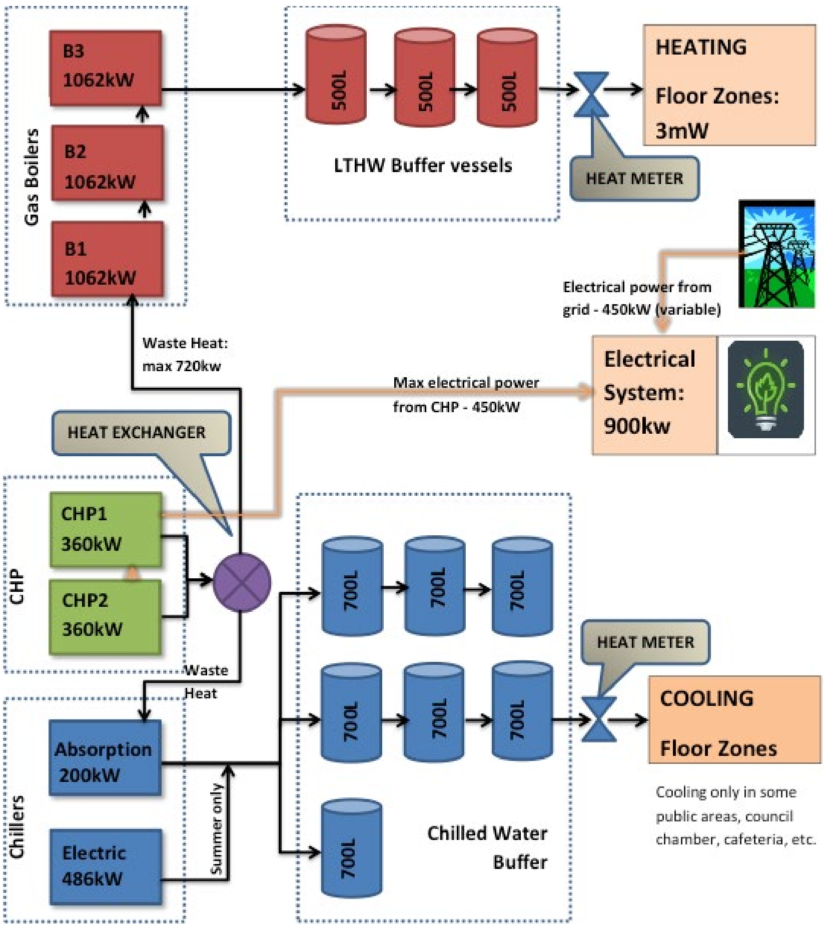
2.1.1_Energy System

A key feature of the refurbishment of the THX is a "bespoke" heating and cooling system. This consists of a condensing gas boiler installation to supply the main space heating load as well as two 358 kWh CHP engines to supply a significant part of the electricity needs of THC (max 900 KW load). During heating periods (daytime) waste heat from CHP engines (330kW) preheats the three 1062kW gas boilers for the main LTHW system. Three 500l LTHW buffer vessels supply floor zones equipped with perimeter radiators controlled by with TRVs are mounted under windows. The connected heating load = 3MW. The main office floors are naturally ventilated and this supports summer cooling (narrow plan floor plate).

Overnight unused/waste heat from CHP is used to feed one 200kw absorption chiller that charges a chiller store of seven 7000l chilled water storage vessels which supports base cooling load for most of the year (the library archive, ICT area and some conference facilities). One 486Kw electric chiller supports additional peak summer cooling load - max 600kW.

A heat exchanger controls waste heat flow from the CHP units to the boilers (330kw max) and absorption chiller (230Kw max). In low occupancy periods e.g. overnight one of the two CHP units shuts down (50% turndown ratio). A simplified view of the system is shown in Figure 2.

Figure 2. Simplified Diagram of the Town Hall Extension Complex Energy System.



2.1.2_Metering and Monitoring Infrastructure

The THX refurbishment should conform to three separate sets of UK standards controlling the energy metering and sub-metering:

1. The minimum requirements of Part L of the UK building regulations;
2. TM39 – the Chartered Institute of Building Services Engineers (CIBSE) best practice guide for energy metering. This shows typical examples of good practice. However some aspects go beyond the minimum Part L requirements to show how to supply adequate data for the requirements of Display Energy Certificates (DECs) as well as confirmation with an industry agreement on multi-tenanted buildings developed by the British Property Federation, Useable Buildings Trust, CIBSE and the British council for Offices (CIBSE 2009);
3. BREEAM – the UK Building Research Establishment Environmental Assessment Methodology (BRE Global 2014).

As part of a pathfinder programme, Manchester City Council (MCC) has implemented the UK "Soft Landings" principles (BISRIA 2014) which include, amongst a wide range of requirements, extended aftercare and post occupancy evaluation (explored further below). This anticipates the application of the TM39 recommendations for metering and sub-metering. Publicly funded building projects such as the THX refurbishment are also expected to reach the BREEAM "excellent" standard. This is a credit point based system and there is one credit for effective sub-metering and compliance with TM39 should ensure achievement of the BREEAM credit. The additional quantity and quality of metering installed which exceeds the TM39 requirements/recommendations, as shown in Table 1, has enabled more effective commissioning by the THX energy management team in the soft landings process as well as providing fine grained energy data for Odysseus.

Table 1. Metering and Submetering in the THX.

THX BUILDING Location	HEAT METERS & SUBMETERS				
	Required by TM39	INSTALLED			
	Building Total	N°	TYPE	Floor total	Building Total
Level 1-7 LTHW	7	1/zone	Danfos SONOMETER 1100	8	56
	ELECTRICITY METERS & SUBMETERS				
Level 1-7 Lighting Circuit	7	1/zone	Schneider Power Logic PM750	8	56
Level 1-7 Power Circuit 1 Office Areas	7	1/zone	ditto	8	56
Level 1-7 Power Circuit 2 Service core	4	1/service core/ floor	ditto	4	28
Total	25				196

For energy management and monitoring purposes the floor plate of the building is divided into zones, each with a heat meter on the LTHW circuit and electricity meter on the lighting and power circuits (Figure 3). These report directly to the building energy management system (BEMS) which records usage for the zones under investigation (Figure 4). The BEMs is Trend Energy Manager V2 (IQ3), with a 963 graphic interface. The building supports a number of essential services and the city ICT management remain very protective of the BEMs integrity. These security concerns (safeguarding the BEMS itself and the internal computer system and firewall), as well as the large volume of data to be processed have caused a number of technical issues in

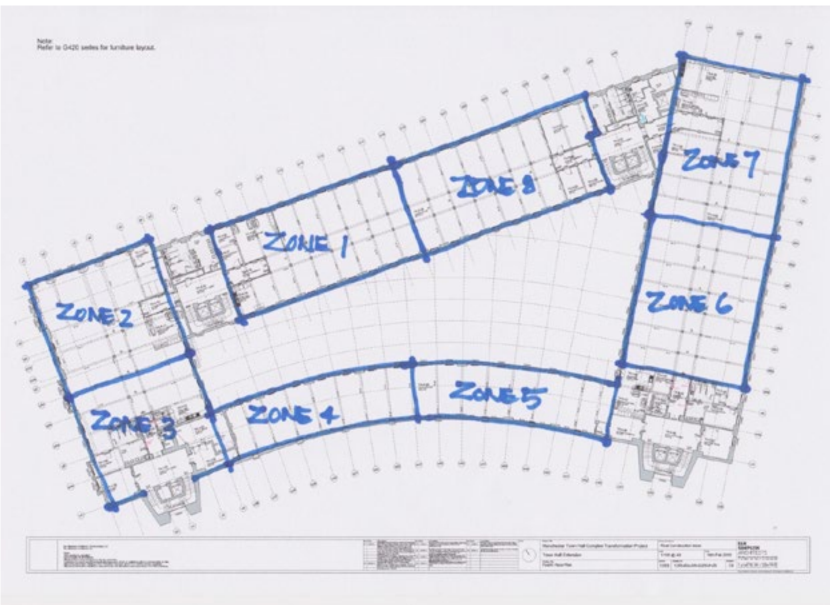


Figure 3. Energy Monitoring - Floor Zones.

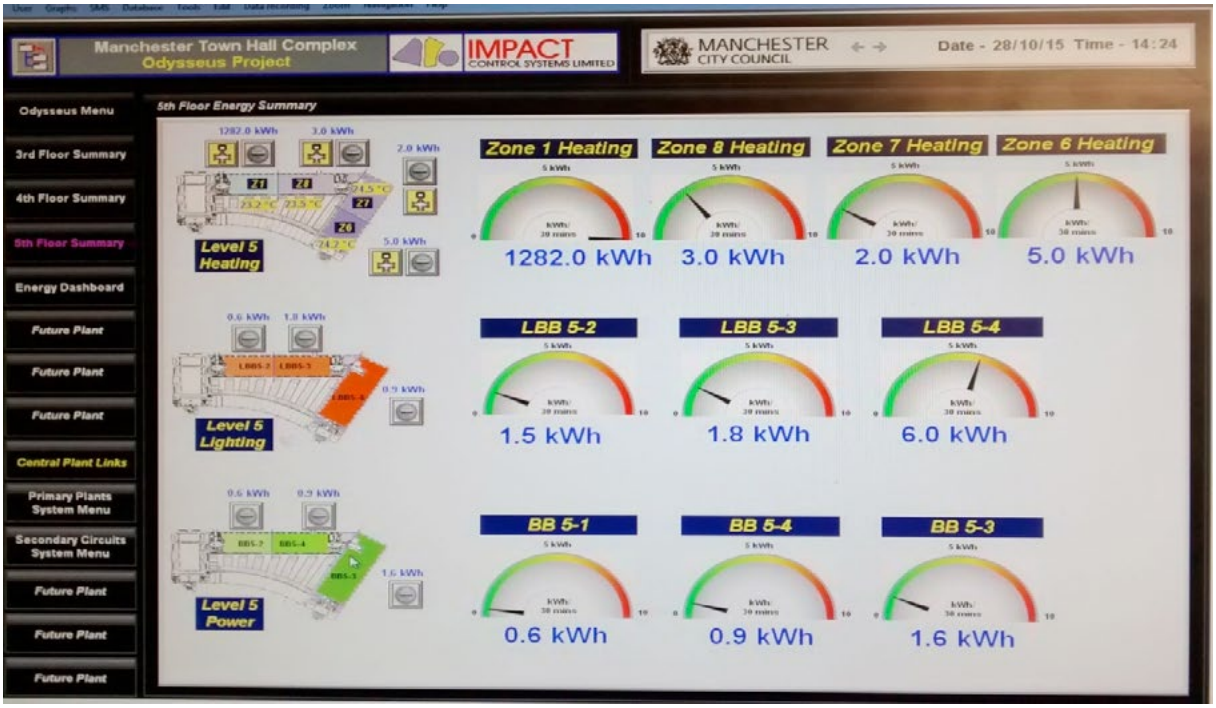


Figure 4. Building Energy Management System - Monitoring of Meters.

providing remote access to the real-time data as originally envisaged for the Odysseus project. To overcome these problems the BEMs exports data to the Odysseus data platform by email on a weekly basis each Sunday at midnight – the time of least system demands. Additional sensors have been installed in the zones on Level 3, 4 and 5 being monitored directly by Odysseus to provide additional real-time data relating to comfort, CO_2, humidity and temperature.

2.1.3_Soft Landings and the THX

Odysseus has worked in parallel over the two year period from practical completion early in 2013 until the systems were fully handed over in March 2015, during which time the city has acted as a pathfinder for the UK "soft landings" protocol. Soft landing is a building procurement initiative where, after practical completion, designers and constructors stay involved with buildings well beyond the normal commissioning period (this is normally for an additional year, i.e. 2 rather than 1 year), The aim is to assist the client during the extended period of operation, to support the fine-tuning and de-bug the systems, to ensure the occupiers understand how to control and best use their buildings so that the anticipated energy and CO_2 targets are met in occupation.
The initial analysis undertaken as part of this process revealed that the building's thermal performance is relatively stable. The CHP units generate heat energy as a by-product of electricity generation and this heat energy is used to the capacity of the spaces in the complex in the heating season and thermal comfort conditions are maintained even if and when users leave windows slightly ajar for ventilation. Lighting is automatically controlled through passive infrared sensors (PIRS) so the occupants' only control over electrical energy consumption is primarily through small electrical power devices (computers, phone chargers, desk fans, etc.). Desk sockets are restricted to 3 amp appliances which prevent high power devices such as heaters being used (if staff do attempt to use such appliances, there is an automatic cut-off of their desk islands power which can only be re-set by facilities management). For

each zone small electrical power energy use is very small – the order of 1.25-1.5kw, therefore the behaviour of individual users causes little effect on energy use. Overall the building is meeting the targets set despite a 30% increase in the level of occupancy. The increase in gas usage reflects the usage in the CHP to generate electricity.

Table 2. Town Hall Complex Energy Use before and after Refurbishment.

ELECTRICTY	BEFORE	AFTER	GAS	BEFORE	AFTER
Month	2008 - 09 kWh	2013 - 14 kWh	Month	2008 - 09 kWh	2013 - 14 kWh
Dec	380,186	289,040	Dec	937,121	590,782
Jan	373,649	351,544	Jan	937,121	748,116
Feb	380,460	345,474	Feb	846,432	751,903
Mar	409,135	378,487	Mar	937,121	905,952
Apr	341,676	363,654	Apr	422,562	463,553
May	362,255	372,432	May	140,927	328,002
Jun	348,067	368,814	Jun	136,381	250,474
Jul	348,331	359,497	Jul	129,575	355,665
Aug	305,201	256,558	Aug	35,433	414,926
Sep	315,857	207,006	Sep	34,290	514,931
Oct	348,680	226,307	Oct	352,834	650,113
Nov	358,312	253,297	Nov	816,970	613,303
Total	4,271,808	3,772,108	Total	5,726,764	6,587,720

However deeper examination of the data has revealed that further savings can be made particularly with the base load electrical consumption (the energy needed for operating the building systems) and lighting and it is these areas are where further efforts to make savings have been concentrated. A number of Energy Conservation Measures (ECMs) were identified as having potential (11), of which 7 have ultimately been implemented. As an example of this work the next section describes one of these: out-of-hours switch-out of lighting on the office floors.

2.1.4_Lighting Study

The lighting in the THX is provided by 500lux fluorescent units (suitable LEDs were not able to be identified at the time of refurbishment) located ceiling pods. In the original installation these were controlled solely by PIR sensors and at the perimeter by daylight sensors (variable from 100% down to 20%) to maximise use of available daylight – as shown in Figure 5. Overall 30% of the lighting in each zone has this additional control. For normal occupancy periods the system worked very effectively. However managers noticed that when the building was unoccupied, after working hours and at weekends, large areas of lighting remained switched on. The office floors in the building are naturally ventilated and it has been shown that if windows are left open overnight as is often the case in summer the blinds have a tendency to move in the breeze and this can activate the PIR sensors. At other times of the year security staff when doing their rounds trigger the PIR sensors. As a result the lights remain on in areas when not required and lighting energy is wasted. Figure 6 shows the lighting energy consumption for Zones 6 and 7 combined on Level 5 for a typical week Monday to Sunday (26/1/15-1/2/15). The base load from the lights being switched-on overnight of 0.8 – 0.9 KW can be clearly seen.

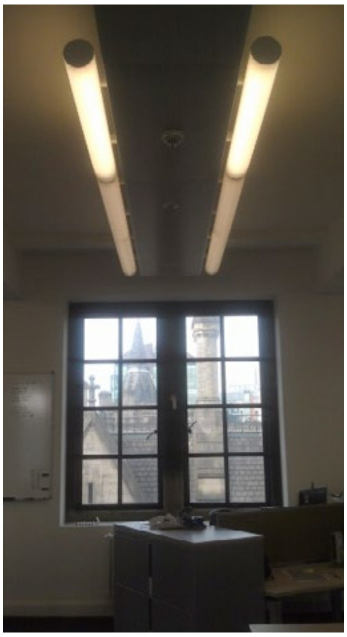


Figure 5. Typical Lighting Pod in the THX Office Floors.

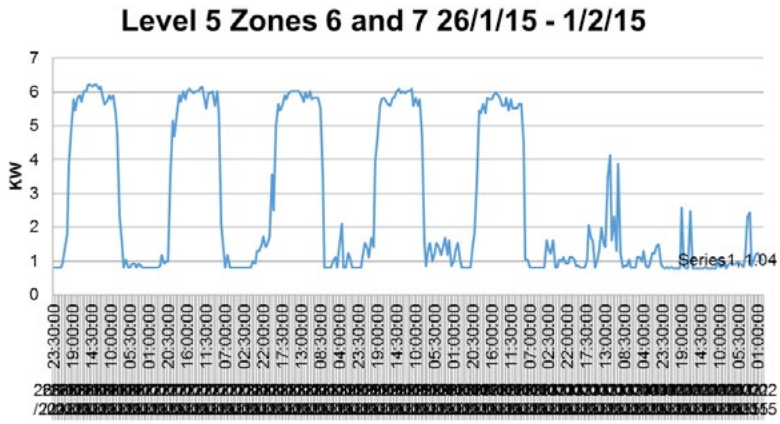


Figure 6. Weekly Plot of Lighting Energy Consumption ***before*** *Floor Plate Lighting Time re-Scheduling.*

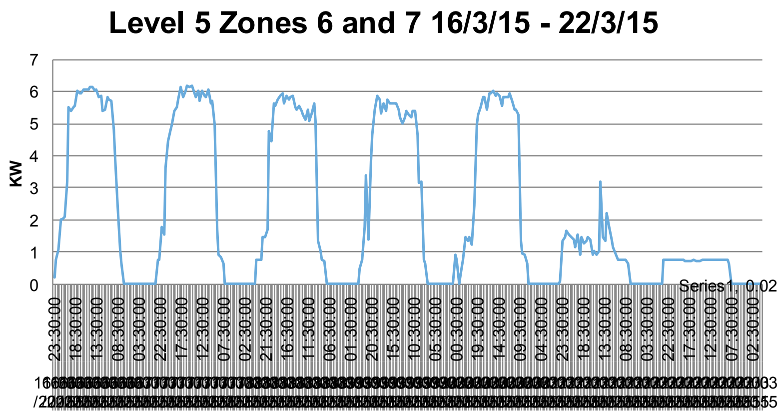


Figure 7. Weekly Plot of Lighting Energy Consumption ***after*** *Floor Plate Lighting Time re-Scheduling.*

From mid-February 2015 the BEMs control has subsequently been adjusted to automatically switch-off the office floor plate lighting centrally after working hours. The ECM that has been applied is THX Floor Plate Lighting Time re-scheduling. The re-scheduling means that the lighting is normally switched off from 10:00pm to 6:00am and at weekends. The security service has the ability to overrule this in any particular floor zone, for example, for weekend working, special events or in emergencies. The removal of the baseload consumption overnight can be clearly seen in Figure 7 which shows the consumption for a typical week after the ECM has been applied. Examination of other zones shows a lower overall consumption (related to the size and occupancy of the space) but nevertheless a similar pattern of overnight base load can be observed with this load being removed after the ECM has been applied (Figure 8). This constitutes a saving of around 0.5KW per hour or 28 KWh/week for each zone, a saving of 1568 KWh/week for all 7 of the office floors in the building and a total saving of around 80MWh/year. This saving has been achieved for minimal cost (a few minutes re-programming of the BEMs).

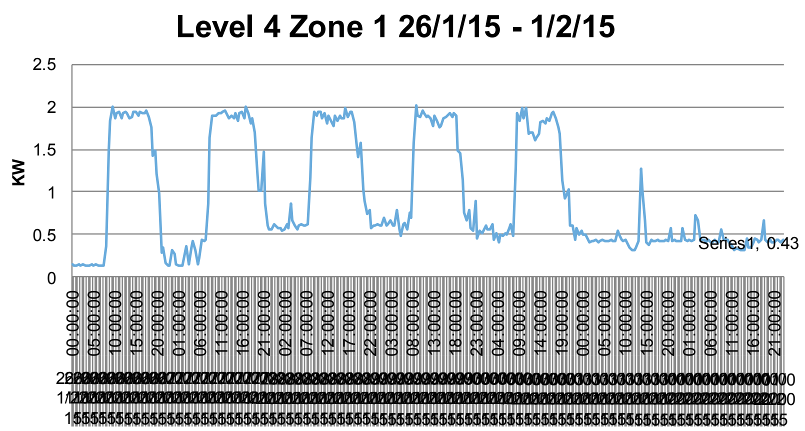
3_Conclusions

This paper has drawn attention to the importance of fine grained sub-metering as a tool to enable:

1. Identification of potential energy savings in buildings at low or no additional capital cost to building owners and;
2. More effective diagnosis of problems in building energy performance during the commissioning phase.

The former assists in both with the requirements of the UK Soft Landings process as well as seeking to meet the expectations of the EU energy evaluation protocols (EEMeasure 2014), which generally expect a full calendar year's data on building energy performance as a baseline against which ECMs can be evaluated. This is a sound requirement because it is important to understand performance and potential energy savings in all seasons of the year. However as described above there are many barriers to reliable data acquisition, in addition to the issues with the BEMS data export described above, there is a need to improve system reliability (problems in this project included meter failure, data recording failures, communications glitches, etc.), which make it technically challenging to acquire a complete 12 months of data at the level of granularity attempted in this pilot study. However, as shown in the example above, fine-grained energy metering can be useful as a short term tactical operational level where savings can be identified and instigated in parallel with longer term monitoring. Experience in this project suggests that the EU protocols could be adjusted to explore effective use of shorter period baseline data. Longer term consumption data is needed more at the whole building level to inform tariff negotiations with energy suppliers and for more strategic infrastructure planning, such as the proposed Manchester Civic Quarter Heat Network.

Point 2 above is particularly important as recent studies in the UK have drawn attention to the number of new, so called "green" buildings that fail to perform, either in terms of energy efficiency targets and/or in some cases in overall comfort. This study has highlighted the considerable importance of



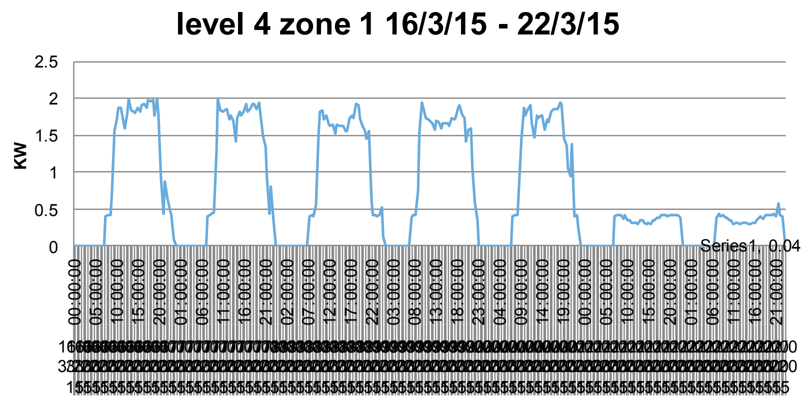


Figure 8. Weekly Plot of Lighting Energy Consumption before and after application of the ECM.

Soft Landings or similar commissioning processes in the delivery of design expectations related to CO_2 targets and energy efficiency savings.

In both cases the potential for unintended consequences of design selection decisions cannot be underestimated. The particular example explained in this paper shows the need consider furnishings alongside overall energy design. The blinds installed in the THX are composed of free hanging veins and work effectively as a low cost solar glare control for workplaces near the windows. However they are free to move in the breeze when windows are opened for fresh air and/or cooling. Blinds in a track would have increased capital costs but they offer a better technical solution that would prevent the blinds triggering the lighting when windows need to be open for ventilation and spaces are unoccupied.

The problems of security in providing remote real-time access to BEMs caused serious delays in developing the Odysseus project whilst solutions to address both data management and security issues were explored. This forms a potential barrier in urban energy management research and development, which will require innovative technical solutions plus skills development in energy research and management. Other research and development engineers should be aware that the assumption that the BEMs systems can easily feed data via the internet is incorrect. BEMs are in fact, first and foremost, stand-alone building management tools, and this is especially true in high profile buildings supplying crucial security sensitive services, e.g. in government and financial sectors. BEMS are not designed to export data to a third party without additional features installed. Without advanced security protection, BEMS should NOT be seen as IOT (Internet of Things) devices.

Ongoing work in Odysseus is using the fine grained data that has been acquired to support the simulations of part of the proposed MCQHN. Initially the data has been used to create experimental versions of the Odysseus dEPCs (Dynamic Energy Profile Cards) for some of the buildings in the network. Some of this work is described in a companion paper to be presented at SBE 2016 (Böhms & Rieswijk 2016). Gas prices are currently low in the UK so it is cheaper for the city to generate its own electricity for the THX by running the CHP unit to full capacity. In fact the manufacturers recommended for full reliability that the CHP engines should be run at maximum capacity all year round. This scenario is fine for the winter as the waste heat from the CHP is used to supplement the space heating in the THX however, at present one engine has to be shut down in the summer because there is a risk of serious overheating. Therefore further research work will run simulations to explore heat export, for example, keeping both engines running flat-out in the summer and exporting heat to adjacent buildings – e.g. the Manchester Art Gallery or to a heat store (also proposed as part of the network). This will provide additional understanding of the potential energy savings and the cost and benefits of constructing the network, viz-a-vie investment in infrastructure and energy storage. It is anticipated that this will provide stronger evidence that being part of a network makes more sense for the city and also give additional incentives to explore further energy efficiency gains in all the civic buildings in order to maximise the efficacy of energy use in the heat network.

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Odysseus Project Team.

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THE ODYSSEUS MONITORING AND DSS (DECISION SUPPORT SYSTEM) SOLUTIONS

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Abstract

The aim of the Odysseus project (1) is to design and develop a platform with the goal of reduce energy consumption on urban areas (\'neighbourhoods\') by improved energy management. To do that, Odysseus platform offers services to perform predictions and simulations using the E-Node data (Node in an energy network that consumes, produces and/or stores energy). These services are consumed by external applications which have been developed to help end users of the platform to make decisions in order to improve the energetic efficiency of the E-Nodes. This paper shows three tools developed by the European Odysseus project members that make use of all capabilities offered by the platform: ***Monitoring tool****: Web Application that provide access to the devices deployed at the pilot sites (Manchester and Rome) to support: Data collection Device configuration* ***eveCity****: The eveCity (for \"Enriched Virtual Environment for the City\") software is a platform that implements CityGML models and supports some operational offers in a near future at the city or district scale.* ***eConnect@****: eConnect@ is a web application based in Java Portlets to be used for decision support making in middle and long terms. This application presents to stakeholders: city energy manager and facility managers reports based on the information stored by the Semantic Service, the GIS service and the analytics services."*

1_Monitoring Tool

The architecture of the Monitoring tool is based on a Virtual Gateway (remote server) that communicates with the Odysseus Cloud Platform through web services (RESTful) and a collection of e-Gateways in the field. Data collection is managed by the VG by means of a scheduler that "talks" to the e-Gateways periodically to gather data from the end devices. The communication is performed over a TCP/IP socket connection (VPN, LAN, GPRS ...). The physical bridge between the end devices and the VG is supported by the e-Gateways, these devices provide Modbus compliant communication over 802.15.4 layer support to collect the information from the end-devices (meters, counters, comfort sensors, smartplugs …) and deliver notifications and messages.

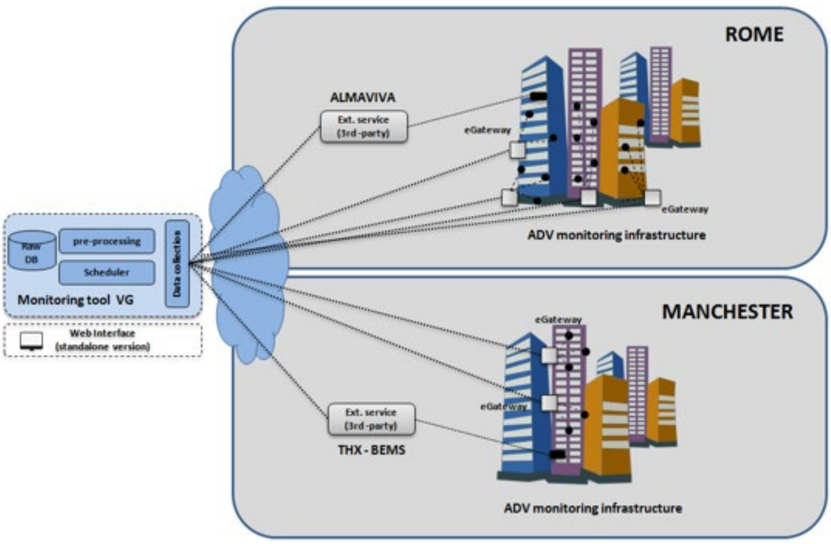


Figure 1. Monitoring Tool architecture.

Additionally the VG enables connectivity solutions (i.e: ftp) and simple API to integrate data from third-party systems (i.e, BEMS, legacy systems, etc.).

1.1_e-Gateway. Data collection & aggregation

A MPC controller acts as bridge between the end devices and the VG, a single MPC controller can manage up to 247 end devices. A Modbus TCP API provides the set of functionalities and security required to access the end devices to perform all the supported actions: device registration, measurement reading, command send and status check. MPC controller manages the end devices associated to it as individual registers with a specific subset of services and protocols supported depending on the type of end devices (i.e: power analyzer, comfort sensor, IEEE 802.15.4, modbus compliant, …). The association between MPCs and end devices defines the hierarchy of the monitoring network. Numberless MPCs are supported by VG in this architecture. (*end*) Devices are queried every few minutes (system configurable) for their information and status and stored in a dedicated database. As often as data are retrieved from end-devices, their status is also checked. A "warning event" will be registered in the system event log when the device does not respond. If after a number of retries (parameter fully configurable), the device is still inaccessible, a new event will be registered reporting the error. System health check is structured into two different levels: firstly, the MPC controller to which all end devices are connected is queried. Then, the controller will regularly query each end device to check their status. On the other hand, the VG scheduler will also check if the required operating system services are currently working (APACHE server, MySQL server) as well as if the data base configuration is correct and accessible. This is implemented through a periodical synchronization process.

1.2_System configuration

The configuration and management options allow the user to register devices, signals, transmission rates, locations and define the configuration parameters. The VG starts to record and store all the information transmitted by the data collection infrastructure deployed; sensors, meters, gateways, repeaters, or any other devices connected to it. Incoming messages are parsed by the VG, the information retrieved is categorised and stored. Raw measurements are pre-processed and the information is stored according to the VG database structure to support the graphic modules.

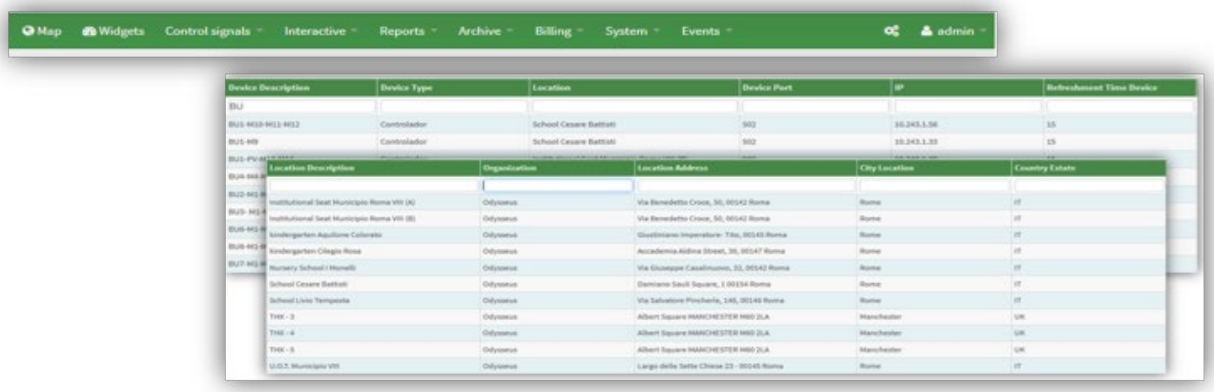


Figure 2. Monitoring Tool Menu bar - devices register and configuration.

1.3_Data display

The Monitoring Tool web interface provides a large subset of graphical features to decide how to display the information retrieved from the monitoring devices. Among other options, widgets, charts, tables, and custom viewers can be selected. Access historic or current measurements in tables and graphical mode, also compare signals, show trends and calculate means and deviations. Third party data integration, ie. weather data/forecasts or geolocation can be seamlessly integrated the VG database. Alarms and notifications associated to events, threshold values or logic combination can be easily set by the user.

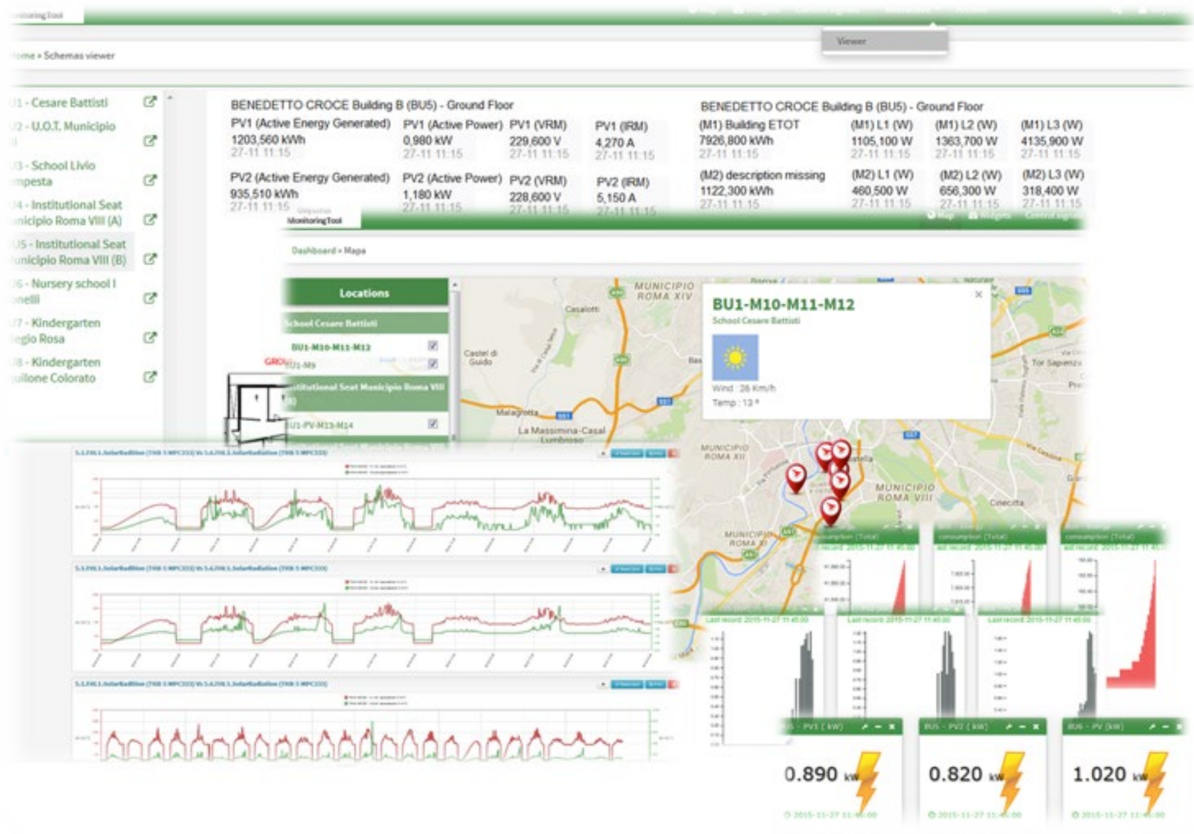


Figure 3. Monitoring Tool Data display features.

2_The simulation and decision support tool

The simulation and decision support tool of Odysseus (2) is based on two main components; the first one is called eveCity. It is a component external to the Odysseus Cloud Platform that connects to the OCP in order to dialogue with the second component called Dimosim that is able to simulate the energy behavior of buildings or a set of buildings.

2.1_EveCity module

Its main goals are to help and support design, decision and finally dialogue, consulting and communication, for project stakeholders. To do so, it interacts with “expert modules” that interoperate in real-time by picking and enriching the model. The results can be displayed within a 3D virtual scene in an integrated, interactive and pedagogical way in order to address non-experts.

In the frame of Odysseus, the developments of eveCity have taken three main directions:

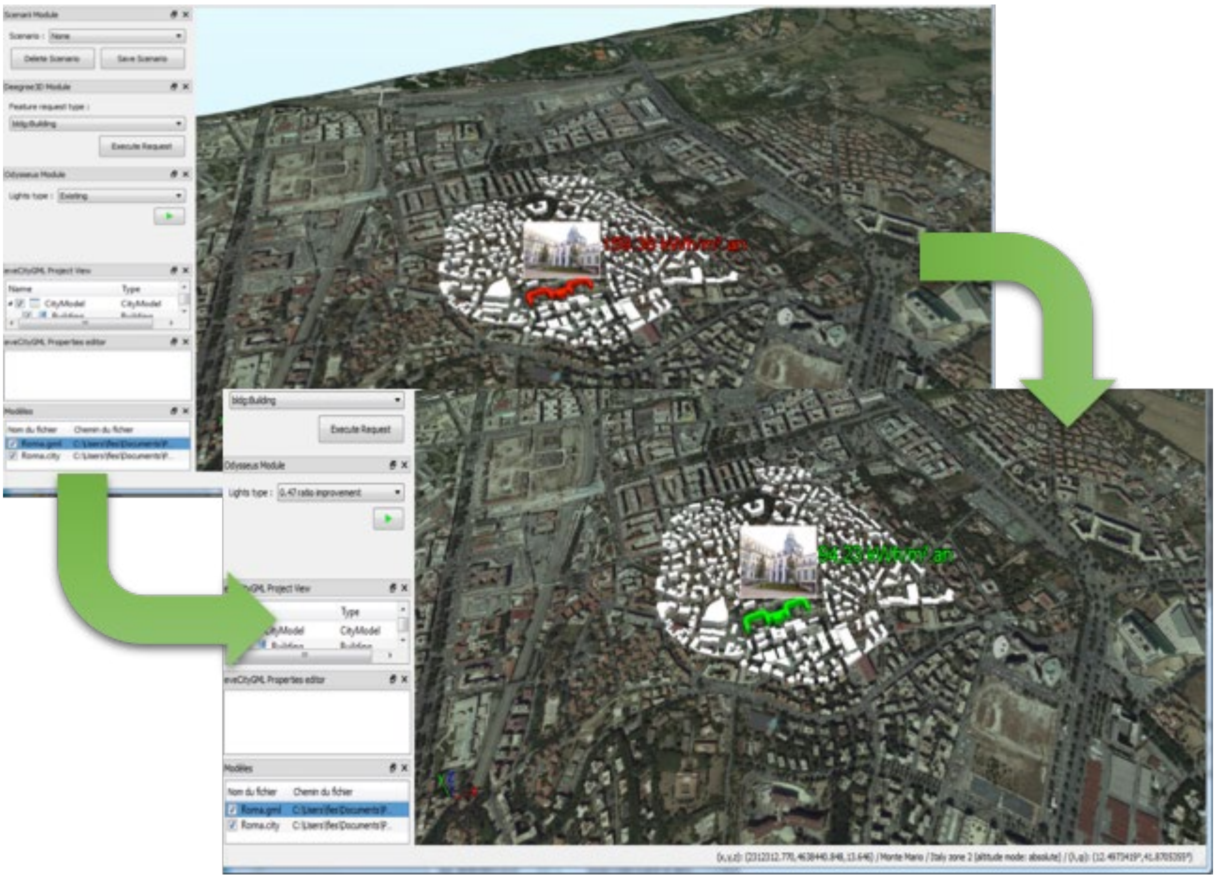
- Connection to a host server to manage city models: it is a GIS server;
- Connection to a data proxy to retrieve energy related information linked with the GIS information;
- Connection to an “analytics module” providing treatments on Energy Data and helping thus in the decision support.

From a technical perspective, as eveCity relies on cityGML for the geo-description of the assets of the considered neighbourhood, the specific expert information that are not supported by the CityGML core model are described via the specific mechanism of Application Domain Extension (ADE). A specific extension has been developed to support the exchange of information related to energy efficiency that follows also the dEPC principles developed in the frame of the project.

2.2_Dimosim

The Dimosim software was initially design to support experts in modeling energy exchanges at the city/neighborhood scale. It is able to import various characteristics of buildings from a CityGML file (buildings location, footprint, associated heights, wall and window properties, air change rates, heating/cooling/DHW systems, etc.) and then perform energy calculation based on statistical building thermal characteristics when these characteristics are not provided by the GML input file. Dimosim generates a detailed energy production/consumption per building and for one year with a resolution step of one hour. In the frame of Odysseus, Dimosin has been identified has the core of the Analytics

Figure 3. Coupling eveCity &Dimosim to support decision making - the Rome Use Case.



component that will be able to process simulation related to the pilots but also comparison between monitored values and simulated ones in order to help the experts in making their decisions.
The development work has consisted in re-writing the code in order to make it compatible with a service architecture and enable thus the dialogue with eveCity and the other components of the Odysseus Cloud Platform.

2.3_The decision support tool

The combination of these two above mentioned components enables to perform various simulations of the energy behavior of a district by simply editing/changing some characteristics of the buildings belonging to this district. EveCity through the notion of scenario is able to store each single configuration and to compare two of them. The interest of that is to make an evaluation of the impact of an ECM (Energy Conservative Measure) on an actual situation, helping thus to find the most adequate changes to apply on the existing district configuration.

3_eConnect@

eConnect@ is a web application dashboard used for decision support making in middle and long terms for the energy efficiency improvement of cities and buildings. The goal of eConnect@ is to consume the information stored in the Odysseus platform to help to the end users to:

- Understand the energetic behaviour and
- Make decisions according to the results shown by the tool

Thanks to the adoption of the dEPC concept, developed in the scope of the Odysseus project, and also implemented by eConnect@, the end users are able to have a holistic view of the element under study: granulized from the detail of the sensors placed inside a building up to a high level vision through organizational divisions such as, neighbourhood, districts, cities, etc.
The decision making is based therefore in two important concepts developed by Odysseus: dEPC and eNode. The most important part of eConnect@ for the decision making is how it combines this information, allowing to the user to have a wide view of the eNodes and their behaviors, so difficult to obtain by other ways, while leveraging the capabilities of the dEPC data aggregation to view aggregated information that would otherwise remain hidden.

3.1_Architecture and specifications

This web application is being developed as a demonstrator of the capabilities offered by Odysseus platform (3), consuming the following services:

- The **GIS Service** such as **wms (Web Map Service)** for representing the map and **wfs (Web Feature Services)** to request for some information related to a component shown in the map.
- The **Semantic Service** through the service published by the **Data Proxy: SelectGatewaysMsg** that requests for **dEPC** information of a given element.
- The **Analitics Services** such as:
  - KPIs calculation offered by the **calculation module**
  - Prediction and simulation services defined in **Dimosim**.

The technologies used are mainly **JavaEE** and **Spring framework** with extensions to use Java Portlets.
The user interfaces are developed using **HTML** with **jQuery** as JavaScript framework. On the server side, this web application is published in a **LifeRay Portal** bundled with **Apache Tomcat server 7**.
The GUI has been designed with the idea to be very simple, user friendly and oriented to a wide range of end users: from home users to city energy manager or facility managers.
It is composed only by two main pages:

- The login page
- The dashboard

3.2_eConnect@ login page

ECONNECT@ has been secured allowing its use only to those users that have been previously registered in the platform.
The users allowed to access to the system are those who:

- exist in the LDAP,
- have **externalApplication** role and,
- are allowed to access to (at least) a pilot site (**tenant**)

It is important to remark that eConnect@ is a multitenant application, allowing this a Software as a Service (SaaS) business model.

3.3_eConnect@ dashboard

The dashboard is the place where the user can interact with the platform, selecting the information to be visualized in a graphical and interactive way or through final reports ready to be printed. The user interface is composed by three portlets interconnected through events:

- Control portlet.
- GIS portlet.
- Data visualizer portlet.

3.3.1_Control portlet

This component, in combination with the GIS portlet allow to the user to filter and select the information source to be visualized in the Data visualizer portlet. Currently there are defined two information data sources:

- **dEPC:** The data represented in the Data visualizer portlet proceed directly from the Semantic Server as was previously aggregated.
- **KPI:** This information comes directly from the calculation module which is the responsible to apply complex algorithm using the dEPC static and dynamic information, i.e: energy consumed (dynamic dEPC information) by surface (static dEPC information).

On the other hand, this component provides also a set of filters to concrete the information to be shown:

- Time range filter: Define the time range of the generated result
- Node scope filter or eNode level: Neighborhood, building or zone of a building
- Time scope: To aggrupate the output values daily, monthly or yearly.

3.3.2_GIS portlet

With the GIS portlet, the user can interact directly clicking on the elements shown in the map, restricting the user interaction only with the elements that are under the user tenant influence. This component uses also the dEPC static information.

According to the Node scope filter selected, the features that can be selected in this component are:

- A set of buildings in case of Neighborhood level selection
- A building
- Or a zone or set of zones of a building, i.e a whole floor, room or an individual sensor

3.3.3_Data visualizer portlet

The data visualizer portlet contains all the logic needed to represent the information provided by the Odysseus platform according to the user selection. The output representations offered by this portlet are:

- Interactive charts.
- Data information tables.
- Report.

4_Conclusions

Despite the fact that these tools are able to show to the end users the energy information of an eNode or a set of eNodes, the capabilities offered by each one are complementary and essentials to support the decision making in order to improve the energy efficiency of the eNodes:

- The **Monitoring Tool** shows the historical and current information (RAW information) that the sensors are obtaining from the eNodes.
- On the other hand, **eConnect@** is a tool developed to represent the static and dynamic information stored in the dEPC as well as the result of combine that information into a KPI.
- Finally **eveCity**, in combination with **dimosim**, are the tools in charge of applying simulation and prediction operations to the data stored in the dEPC, allowing modeling new eNode behaviors after applying changes that implies energy efficiency improvements.

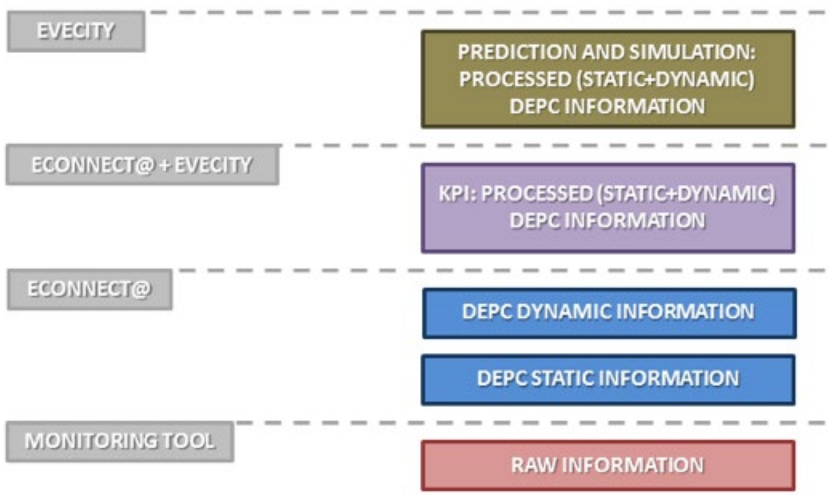


Figure 4. Decision making tools comparison.

Moreover, these tools have been developed to consume the services offered by a platform in the cloud, the Odysseus platform. This allows to these tools to improve and increase easily their offered functionality when using new services from other similar platforms, such as URB-Grade (4) or Ambassador (5) that use also the dEPC concept (6) and offer a set of data analytics and prediction and simulation services in the cloud.

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